THE

# AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

## Art. VII.—Henry Draper.

Henry Draper died at his residence in New York City, on the 20th of November last. He had entertained the National Academy of Sciences at dinner on the evening of the 15th and went from the table to his bed with a severe attack of pleuritis. Hope alternated with fear until Sunday, when pericarditis developed and, in spite of the best medical skill, he died about four o'clock on Monday morning.

Professor Draper's career has been an exceptionally brilliant one. He was born in Virginia in 1837, his distinguished father, John William Draper, being at the time Professor of Chemistry and Physiology in Hampden Sidney College. Though he attended in early life the primary and preparatory schools of the University of the City of New York (to which place his parents removed when he was only two years of age) and subsequently became an undergraduate student at the same University, his real education was received in his own home. The eminence of his father as a teacher, an author, a philosopher and an investigator, created an atmosphere of scientific culture about him of the highest tone. It could not but happen, that Henry, breathing constantly such an atmosphere, should be permeated with its spirit and early devote himself to research s the highest attainable purpose in life.

At the age of twenty, and before taking his medical degree, he made his first research, which was afterward published as his graduating thesis. It was on the function of the spleen and

was illustrated with microphotographs of great excellence. This early study of photography led him to the discovery of the value of palladious chloride as an intensifier. From this time dates his interest in the photographic studies in which he afterward attained such eminence. Shortly after graduation he spent a year in Europe, and made a visit to Lord Rosse at Parsonstown, Ireland. Here he saw the great reflector so well known to science, and became very much interested in it, because of its photographic possibilities. Upon his return he set about constructing a metal speculum fifteen inches in diameter, which he completed in 1860. In 1861, owing to a suggestion made by Sir John Herschel to his father, he abandoned speculum metal and made several mirrors of silvered glass 15½ inches in diameter. The details of the construction and mounting of these mirrors were published as a monograph, in 1864, by the Smithsonian Institution. With this instrument a great amount of astronomical photography was done, the piece of work best known being his photograph of the moon. In perfection of detail it was far in advance of any previous attempt. The original negatives, of which over 1500 were taken, were about an inch and a quarter in diameter and they bore enlargement to three feet, and in one case to fifty inches, with excellent results. In 1870 he finished a second and larger reflector. Its mirror was also of silvered glass, twenty-eight inches in diameter: and like the former one, was ground, polished, corrected, silvered and mounted solely by himself. The first telescope had been mounted in the Newtonian form. The new one was equatorially mounted and at first of the Cassegrainian form; but subsequently he improved it by making the secondary mirror plane. In 1875 an achromatic refractor of twelve inches aperture, made by Alvan Clark & Sons, was placed upon the same axis. And in 1880 this was exchanged for a telescope of a little less aperture, but furnished with an extra lens as a photographic corrector. A five-inch finder completed this unrivalled photo-telescopic battery. All these instruments were mounted in an observatory built on his father's grounds at Hastings-on-Hudson. At first, it consisted of but a single dome, containing the 15½-inch reflector; but subsequently, a second and larger dome was added, and also the rooms needed for the transit instrument and chronograph, the photographic laboratory and the workshop. Though a wooden building of but one story, unpretending in appearance, its internal arrangements were admirable, and its facilities for astronomical photography entirely unsurpassed.

The work at the observatory was done chiefly during the summer months; Dr. Draper residing then at his country place at Dobbs Ferry, two miles distant. In the winter, he carried

on investigations at his house in New York, those being selected for the purpose which did not require a telescope. At first, two rooms in the third story were devoted to these researches. But in 1880 he built a special physical laboratory as the third story of his stable in the rear of his house, this laboratory being connected with the house by a covered way. The equipment of this laboratory was superb. A siderostat by Alvan Clark & Sons, placed upon the roof, furnished abundant sunlight, directed to any part of the room by a secondary mirror. An Otto gas-engine of four-horse power gave motion to three dynamo-machines for the production of electric currents. One of these was a Gramme machine, wound double, and which by an ingenious modification of his own, could be made to give a continuous or alternating current at will. The second was an Edison machine, used mainly to light the laboratory by means of incandescent lamps. The third was a Maxim machine used for producing arc lights and also to feed the field of the Gramme machine. For the production of the electric spark, an induction coil of the largest size was employed, made by Ruhmkorff. Used with the direct current it gave 15-inch sparks readily, though the safety points were usually set at 10 or 12 inches to avoid perforation. With the Gramme direct current this coil yielded 1000 ten-inch sparks per minute. With the alternating current, the spark, though silent and only one-quarter as long, was of much greater volume; so that when heavily condensed, the discharge was like the rattle of musketry. The optical and photographic appliances were of the finest. Complete spectroscopes and cameras were there, as well as the lenses, prisms and gratings, of various materials and of the best workmanship, needed to extemporize those in research. A lathe, file bench and carpenter's bench, each with its full set of tools, completed the appointments of this beautifully finished room.

With these facilities at his command, the original work which Dr. Draper did was of an exceedingly high order. Upon the completion of his large reflector, he applied it at once to the photographic reproduction of stellar spectra; and in 1872 he obtained a photograph of the spectrum of $\alpha$ Lyræ (Vega) showing dark lines; a result then unique in science. Continuing his labors he obtained more than a hundred stellar spectra of great excellence; latterly, and especially when he used the photographically-corrected refractor, taking upon the same plate the spectrum of Venus, Jupiter or the moon, for reference. In 1873, he published the finest photograph of the diffraction spectrum ever made. It included upon a single plate the region from wave-length 4350, below G, to wave-length 3440, near O. A steel plate from this photograph was introduced by

Secchi into his great work on the sun, and in 1880 a lithograph of it was published in the Proceedings of the British Association as the most suitable reproduction extant, for determining the wave-length of the fixed lines. The spectrum was obtained with a Rutherfurd grating of 6481 lines to the inch, and in the photo-lithograph a portion of Ångström's drawing is reproduced for comparison with it. In 1876 he succeeded in face of great difficulties, in photographing the solar spectrum and the spectrum of an incandescent gas upon the same plate with their edges in contact; thus admitting of accurate comparison between the lines. He then noticed that, while the lines of the iron and aluminum used as electrodes coincided exactly with their proper dark solar lines, the lines of oxygen corresponded to bright solar lines. He was led to conclude therefore, not only that oxygen actually existed in the sun, but that it existed there under conditions, probably of temperature, which caused it to radiate more light than the surrounding solar masses. At the same time therefore, that he announced his discovery of oxygen in the sun, he proposed an important modification in the theory of the solar constitution. These conclusions were so radical that he deemed no labor too great which should strengthen them. He continued his researches in this direction and early in 1879 produced a photograph of marvellous excellence on a much larger scale which showed the coincidences, especially of groups, so accurately as to leave no longer any doubt upon the subject. He was anxious, however, to obtain conditions which should make the lines of oxygen sharper; and had made special preparation for the accomplishment of this result during the present winter.

While using the gelatino-bromide dry process in stellar spectrum photography, Dr. Draper conceived that the great sensitiveness of these plates might enable him to secure a photograph of a nebula and so to obtain an accurate record of its present condition with a view to future comparisons. On September 30, 1880, he obtained, after an exposure of 57 minutes, a photograph of the great nebula of Orion, which was sufficiently perfect to enlarge. In order to get this much fainter nebula, the plate had of course, to be over-exposed for the stars. On the 11th of March, 1881, a second enlarged photograph was published, much more full in its details, the exposure being 104 minutes. And finally on the 14th of March, 1882, he succeeded after an exposure of 137 minutes, in securing a photograph wonderful in its detail, showing stars of the 14·7 magnitude on Pogson's scale, invisible to the eye, and giving the faint outlying regions of the nebula with absolute perfection. This result must be regarded as the greatest triumph which astronomical photography has yet achieved. Besides these more

difficult photographs, Dr. Draper obtained some excellent ones of the spectrum of the nebula. These are chiefly interesting because, besides the general bright line spectra characteristic of this nebula, they show in several places traces of continuous spectra suggesting condensation.

Professor Draper's preëminence in celestial photography led to his selection in 1874, by the Transit of Venus Commission of the United States, as the Director of the Photographic Department. During the spring of that year, he spent three months in Washington engaged in devising improved methods, in testing instruments and materials, and in instructing those who were to use these methods how to obtain the best results with them. Although he did not accompany any of the expeditions, yet so conspicuous were his services that, upon recommendation of the Commission, Congress ordered a special gold medal to be struck in his honor at the Philadelphia Mint. This medal is 46 millimeters in diameter and has upon the obverse the representation of a siderostat in relief, with the motto: "Famam extendere factis hoc virtutis opus." On the reverse is inscribed the words: "Veneris in sole spectandæ curatores R. P. F. S. Henrico Draper, M.D., Dec. VIII, MDCCCLXXIV;" with the motto: "Decori decus addit avito."

In 1878, Professor Draper organized a party of five persons to observe the solar eclipse of July 29th. The station which he selected for observation was Rawlins, in Wyoming, on the line of the Union Pacific Railroad. The expedition proved an entire success, Professor Draper himself securing an excellent photograph of the corona and also one of its diffraction spectrum, which appeared continuous. Others of the party detected heat in the corona and also faint dark lines in its spectrum. In 1880, Dr. Draper publishe i an account of a photograph he had obtained of the spectrum of Jupiter, which appeared to him to afford evidence that this planet furnishes intrinsic light. The exposure required to get the spectrum was fifty minutes, that of the moon on the same plate being obtained in ten. In June, 1881, he photographed both the comet and its spectrum, using a slit and two prisms for this latter purpose. Three photographs were taken with exposures of 180, 196 and 228 minutes respectively, each having a comparison spectrum upon it.

Besides that spent in scientific work, Dr. Draper's time was largely occupied with his duties as instructor. In 1859 he was appointed on the medical staff of Bellevue Hospital, and served eighteen months. In 1860 he was elected Professor of Physiology in the Academic department of the University of the City of New York; a position which he held until the past year.

In 1866 he was elected to the chair of Physiology in the Medical Department of the University and made Dean of the faculty. He managed the affairs of the college with signal ability and, by a liberal use of his own private means, brought it successfully out of the trying position in which it was placed by the destruction by fire of its building in Fourteenth street. He severed his connection with the Medical School in 1873. For several years he had added Analytical Chemistry to the branches he taught in the Academic Department. Upon the death of his father in January, 1882, he was elected to succeed him as Professor of Chemistry, and gave the instruction in both chairs until the close of the collegiate year, when he resigned his connection with the University entirely.

Still a third portion of Professor Draper's time, and this no inconsiderable portion, has been given during the past ten years to the management of the large business interests in his hands. In 1867 he had married the daughter of Courtlandt Palmer, Esq., and upon his death in 1874, Dr. Draper was elected managing trustee of an immense estate, and was obliged to devote himself energetically to the work of reducing it to a solid investment basis. His success here has been as signal as in the work of scientific research and of instruction.

In 1861 Dr. Draper was appointed Surgeon of the Twelfth New York Regiment and served as such with distinction. In 1876 he was appointed a Judge in the Photographic Section of the Centennial Exhibition. In 1877 he was elected a member of the National Academy of Sciences and a member of the American Philosophical Society. In 1879 he received the election of Fellow of the American Association for the Advancement of Science. He was made a member of the American Academy of Arts and Sciences in 1881 and of the Astronomische Gesellschaft in 1875. In 1882 he received almost simultaneously the degree of LL.D. from his *alma mater* and from the University of Wisconsin.

Professor Draper's abilities were many-sided. In science, he was eminent in astronomy, in physics, in chemistry and in physiology. He was exceedingly able as a mechanician, as the telescopes in his observatory with their wonderfully accurate mountings, can testify. As a teacher he was clear, precise and considerate. As a business man he is said to have had no superior in the city of New York. In social life he was brilliant, entertaining, companionable. He made life-long friends often at the first contact, by the suavity of his manner and the charm of his presence. To get rest from the severe labors of the year and to fortify his constitution for the winter's strain, it had been his custom for eight years, to join his friends, Generals Marcy and Whipple of the U. S. army, for a month's hunt

in the Rocky Mountains during September. These expeditions he enjoyed greatly. He was an enthusiastic sportsman and a capital shot; and he entered upon the hunt with as much relish as he took a photograph. It was while out on such an expedition in 1877 that he made the important observations upon the suitableness of the air of that region for astronomical investigations. In 1882, the party was absent two months, traveling on horseback from the Union Pacific to the Northern Pacific Railroad; and when above timber line he was exposed to a severe and intensely cold snow storm.

Professor Draper had not published very extensively at the time of his death. This is the more remarkable as he was fond of writing, a trait no doubt inherited from his father. A list of his publications is appended to this notice. There can be little room to doubt that had he not been cut down so abruptly in the midst of a host of projected investigations, the world would have been enriched during the next twenty years with a wealth of discovery almost unparalleled.

Looked at from any stand-point, the death of such a man as Henry Draper cannot be viewed but as a calamity. At the age of 45 years, with very many years of good work apparently before him, with the experience and learning of the twenty years past added to a rich and varied natural endowment, giving promise of a scientific career of exceptional brilliance, it is no wonder that the world of science mourns his departure. Moreover he seemed to be just ready for his life-work. He had completed the building and equipment of his observatory and laboratory, and had arranged everything ready for experiment. He had given up his professorship and was reducing his business cares in order to get more time for research. He had stored his mind for years with precious facts which he hoped now to utilize in the highest investigations. Finally he had a most devoted wife who always acted as his assistant, and to whose skilled hand and thoroughly trained eye he has attributed much of the success he had already attained. Such men it is that the world is made poorer by losing. They are all too few, and when one drops from the ranks of honest and earnest workers, the gap is never completely filled. G. F. B.

---

### List of Henry Draper's Original Papers.

1. On the Changes of Blood Cells in the Spleen. *New York Journal of Medicine*, III, v, 182–189, Sept., 1858.

2. On a new Method of Darkening Collodion Negatives. *Am. J. Phot.*, II, i, 374–376, May, 1859.

3. On a Reflecting Telescope for Celestial Photography. *Rep. Brit. Assoc.*, 1860, II, 63–64.

4. On the Photographic use of a Silvered Glass Telescope. *Phil. Mag.*, IV, xxviii, 249–255, 1864.

5. On a Silvered Glass Telescope and on Celestial Photography in America. *Quar. J. Sci.*, i, 381–387, Apr., 1864.

6. On the Construction of a Silvered Glass Telescope 15½ inches in aperture, and its use in Celestial Photography. *Smithsonian Contr.*, XIV, Part II, July, 1864.

7. Petroleum; its Importance, its History, boring, refining. *Quar. J. Sci.*, ii, 49–59, 1865. *Dingler's Polyt. J.*, clxxviii, 107–117.

8. American Contributions to Spectrum Analysis. *Quar. J. Sci.*, ii, 395–401, 1865.

9. A Text-book on Chemistry. New York, 1866.

10. Report on the Chemical and Physical facts collected from the Deep Sea Researches made during the voyage of the Schoolship Mercury. *Rep. Comm. Pub. Charities*, New York, 1871.

11. On Diffraction Spectrum Photography. *Am. J. Sci.*, III, vi, 401–409, Dec., 1873. *Phil. Mag.*, IV, xlvi, 417–425. *Ann. Phys. Chem.*, cli, 337–350, 1874.

12. Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from 4500 to 11000 feet in Utah and Wyoming Territories and Colorado. *Am. J. Sci.*, III, xiii, 89–95, Feb., 1877.

13. Photographs of the Spectra of Venus and $\alpha$ Lyræ. *Am. J. Sci.*, III, xiii, 95, Feb., 1877. *Phil. Mag.*, V, iii, 238.

14. Discovery of Oxygen in the Sun by Photography and a new Theory of the Solar Spectrum. *Proc. Am. Phil. Soc.*, July, 1877, 74–80. *Am. J. Sci.*, III, xiv, 89–96, 1877.

15. Observations on the Total Eclipse of the Sun of July 29, 1878. *Am. J. Sci.*, III, xvi, 227–230, 1878. *Phil. Mag.*, V, vi, 318–320.

16. On the Coincidence of the Bright Lines of the Oxygen Spectrum with the Bright Lines of the Solar Spectrum. *Am. J. Sci.*, III, xviii, 262–277, 1879. *Monthly Not. Astr. Soc.*, xxxix, No. 8.

17. On Photographing the Spectra of the Stars and Planets. *Am. J. Sci.*, III, xviii, 419–425, Dec., 1879.

18. On a Photograph of Jupiter's spectrum showing evidence of Intrinsic Light from that Planet. *Am. J. Sci.*, III, xx, 118–121, 1880. *Monthly Not. Astr. Soc.*, xl, 433–436.

19. On Photographs of the Nebula in Orion. *Am. J. Sci.*, III, xx, 433, 1880. *Phil. Mag.*, V, x, 388. *C. R.*, xci, 688; xcii, 173, 964.

20. On Photographs of the Spectrum of the Comet of June, 1881. *Am. J. Sci.*, III, xxii, 134, 1881.

21. On Photographs of the Spectrum of the Nebula in Orion. *Am. J. Sci.*, III, xxiii, 339–341, May, 1882.

ART. VIII.—*On a remarkable Fauna at the base of the Chemung Group in New York;* by HENRY S. WILLIAMS, PH.D., Cornell University.

MORE than a year ago the writer discovered, at the base of the Chemung Group at Ithaca, N. Y., two species of Brachiopods, which were hitherto regarded as peculiar to more western deposits, and a different geological horizon in America. These are a species of *Productus* described by Professor Hall as *P. dissimilis* (Iowa Geol. Rep., vol. i, Pt. II, p. 497), (entirely distinct from *P. dissimilis* of DeKoninck), and the form of *Rhynchonella* referred to Martin's species, *R. pugnus*, by Meek, in the Illinois Geological Report, iii, p. 450. Both species are decidedly Carboniferous in aspect. Their lowest range in the West is in beds referred to the Kinderhook group of Meek and Worthen, and to the Chemung, and to the Hamilton groups of the East.

During the summer of 1882 a fossiliferous stratum was examined a few miles south of Canandaigua Lake, at High-point, Naples, N. Y., containing *Productus dissimilis*, varietally identical with the Ithaca form, and a variety of *R. pugnus* type, but more like the species *R. acuminata* of Martin than the Ithaca or Iowa specimens. With these, a rich fauna was seen, the species of which are almost all different from the normal species of the New York Chemung fauna.

The author is indebted to the kindness of Professor J. M. Clarke, of Northampton, Mass., and Mr. D. D. Luther, of Naples, N. Y., for the discovery of these Naples beds. Recent examination of the material there collected reveals a fauna of more than ordinary interest.

The Ithaca rocks under consideration are, stratigraphically, about five hundred and fifty feet above the top of the Genesee slate, near the head of Cayuga lake.

In this section the Portage rocks are about three hundred feet thick. The Naples rocks are near the summit of an abrupt hill, called High-point, and lie about twelve hundred feet above the highest Genesee slate of that meridian, the dip being very slight.

The High-point fauna is in a calcareous stratum, of local extent, in the midst of brownish gray sandstones and shales. The stratum is made up of a mass of Crinoid stem fragments, shells, mainly Brachiopods, corals and Bryozoa, and what appear to be pebbles of a soft greenish shale.

The following species have been identified by the author:

***Productus dissimilis*** Hall (not Koninck).
***Rhynchonella pugnus*** Martin (a variety approaching young of ***R. acuminata*** Martin).
***Orthis impressa***, var. ***Iowensis*** Hall.
Fragments of Crinoid stems in abundance.
***Strophodonta arcuata*** Hall.
***Strophodonta arcuata***, var. of the same (="***Str. quadrata*** Calvin.")
***Atrypa aspera***, var. ***occidentalis*** H.
***Fistulipora occidens*** H.
***Fenestella***, sp.
***Spirifer Orestes*** Hall.
***Spirifer Hungerfordi*** H. (a single imperfect shell, but corresponding with this species in all characters preserved).
***Strophodonta canace*** H. and W.
***Strophodonta? reversa*** H.
***Strophodonta***, n. s. (presenting the characters of ***S. reversa***, but not resupinate, as that species).
***Chonetes***, sp.
***Rhynchonella? contracta***, H., '67, p. 417.
Fish Spines (? ***Ctenocanthus***, near the ***C. formosus*** type), and a species of ***Zaphrentis***.

Besides these, Professor Clarke has identified:

"***Streptorhynchus Chemungensis.***"
"***Spirifer disjunctus.***"
"***Extremity of mandible of Rhynchodus.***"
"***Ambocœlia umbonata***," and a few other forms which the author has not seen.

A comparison of this fauna with that of Lime Creek, near Rockford, Iowa, reveals a remarkable likeness, and especially among the species characteristic of the latter fauna. Although *strikingly Carboniferous in aspect*, several of its species are like those of Western "Hamilton" deposits, in which group it is retained by C. A. White, Report on Geol. Iowa, i, 1870. But the appearance of a large majority of the species in rocks, in New York State, known to be in the lowest part of the Chemung group, calls for a reconsideration of the whole question as to the equivalency of the beds concerned.

In 1858 (Iowa Geol. Rept., i, Pt. II), Professor Hall described a number of species from Lime Creek and the neighborhood of Rockford, Iowa, which he then referred to the Hamilton group. Afterwards, upon a more careful study of the rocks and species, Professors Hall and Whitfield described more species from the same beds, and referred the beds to the "Chemung group." (23d Report on Cabinet, New York State, 1873. This paper was prepared for the report of 1869, but was not published till 1873.)

In 1866, Professor Worthen (Illinois Geol. Report, i, p. 108), as had been proposed in 1861, by Meek and Worthen (this Journal, vol. xxxii, p. 167, defined the Kinderhook group as including all the western deposits lying between the Black slates and the Burlington limestone, including these beds of Iowa and their fauna. Leaving the question of the precise limits and horizon of the Lime Creek fauna of Iowa for more thorough investigation, we take this fauna alone for comparison with that of the New York rocks.

The species as described by Hall, 1858, and Hall and Whitfield, 1873, are as follows:

*Orthis Iowensis*,
*Strophodonta arcuata*,
*Strophodonta reversa*,
*Strophodonta demissa*,
*Productus dissimilis*,
*Spirifer Hungerfordi*,
*Spirifer Whitneyi*,
*Atrypa reticularis*,
*A. reticularis*, var. *occidentalis*,
*Strophodonta canace*,
*Cryptonella Calvani*,
*Spirifer Orestes*,
*Spirifer cyrtiniformis*,
*Crania familica*,
*Stromatopora incrustans*,
*Fistulipora occidens*,
*Zaphrentis solida*,
*Alveolites Rockfordensis*,
*Pachyphyllum Woodmani*,
*Pachyphyllum solitarum*,
*Campophyllum nanum*,
*Chonophyllum ellipticum*,
*Cystiphyllum mundulum*,
*Stomatopora alternata*,
*Aulopora saxivadum*.

This is a list of twenty-five species, fourteen of which are Brachiopods. Of the fourteen, eight at least are represented in the fauna at High-point, Naples, N. Y., and constitute the large majority of all the Brachiopods found in that locality.

The *Rhynchonella pugnus* Martin, of beds at Rockford, Indiana, and at Chouteau, Missouri, and other localities of the Kinderhook group, has not been recorded from these Lime Creek beds of Iowa, but the author has lately examined specimens from beds of apparently the same horizon in the central portion of Iowa, which are identical with the Ithaca variety of *R. pugnus* Martin.

The Lime Creek fauna is certainly more closely related to the fauna of the Kinderhook group of Missouri, Indiana and Illinois than to any other fauna of the West, and contains some peculiar forms, and in the present state of information it seems appropriate to refer it to the Kinderhook group.

This *Rhynchonella pugnus* Martin, first identified by Meek, in Illinois, Geol. Rept., vol. ii, p. 154, and vol. iii, p. 452, appears to have confused several writers. In this country it is first referred to in 1855, in the Missouri report, as *Rhynchonella Missouriensis* Shumard. Only the first of the figures given by Shumard represents this species, as was shown by Mr. Meek, (i. e., Pl. C. fig. 5*a*.)

In 1860, Professor Hall described a form from the Goniatite beds of Indiana, under the name *Rhynchonella* (*Eatonia*) *obsolescens* (13th Rept. on Cabinet N. Y., p. 111). This species cannot be distinguished, so far as the description goes, from the *R. pugnus* Martin, later recognized in the same beds by Meek.

In a paper read before the Iowa Academy of Sciences, in 1877, Prof. S. Calvin described, under the name *Rhynchonella alta*, a species from the Iowa beds. Specimens of this form, lately examined by the author, are identical with the variety of *R. pugnus* met with in the Ithaca beds. This *Rhynchonella* is a peculiar type and is easily distinguished from anything else appearing in the Upper Devonian, or Lower Carboniferous of America.

The representative met with in the High-point beds (Naples, N. Y.), as before mentioned, offers varietal differences in which it approaches the European forms, called *R. acuminata*. One specimen is almost identical with the figure of *R. acuminata* Martin, var. *mesogonia* Phill., given by Davidson on Plate xxi, fig. 3, of his British Carboniferous Brachiopods. It differs from the other representatives of this type before mentioned, in a greater and more angular production of the median fold, and in the sharpness of the plications of this fold, but it differs from the typical *R. acuminata* Martin in the possession of threo distinct, but very short, plications at the margin, outside the median fold, a character distinguishing *R. pugnus* from *R. acuminata*. Of the same type, and it may be same species with above, are *R. Eatoniæformis* McChesney, of the Coal-measures of Illinois, *Terebratula Rocky-montana* and *T. Uta* of Marcou, from the Carboniferous of Salt Lake City, *Rhynchonella Osagensis* Swallow, of the Carboniferous of Missouri, and of Danville, Illinois, and "*Camarophoria globulina* Phillips," as identified by Geinitz, from the Carboniferous at Nebraska City. The typical *R. acuminata* and *R. pugnus* Martin are found associated in British and European Carboniferous beds, and appear in the Devonian.

The American representatives are much smaller than those of the other side of the Atlantic, and, whether we regard them as identical species, or not, there can be no doubt that they are the American representatives of this type.

Now, turning to the Ithaca beds, we find there a fauna, near the base of the Chemung group, in which are species peculiar to the High-point fauna of Ontario Co. and these disputed western deposits, and not known from any other localities in America. These are *Rhynchonella pugnus* Martin, *Productus dissimilis* Hall, *Fistulipora occidens* Hall and *Zaphrentis solida* Hall; and with them, *Cryptonella eudora* Hall occurs in the same

beds, and is so closely related to *C. Calvani* of the Iowa beds that Professor Hall originally referred it to that species.

The association of these peculiar forms in these several localities leads to an overwhelming probability of the actual equivalency of the deposits containing them.

The species of Lime Creek, near Rockford, Iowa, and of High-point, Naples, Ontario county, N. Y., are so strikingly similar that one can scarcely doubt the presence of a common fauna. And the presence in the Ithaca beds, at the same horizon with the High-point beds in Ontario county, of a few of these peculiar forms, persuades us that we are still considering stragglers from the same western fauna, in the very midst of the typical fauna of the Chemung group.

What are the bearings of these facts upon the stratigraphical relations and equivalency of the beds concerned?

In the first place the Ithaca horizon is at a point where we first meet, in ascending, the characteristic Chemung fauna—the first fauna above the Portage group. The higher Chemung fauna, as it appears at Chemung Narrows, N. Y., does not come in to the deposits of this meridian until after the deposition of six hundred feet of coarse sandy shales. The High-point fauna (of Ontario county, N. Y.) is also the earliest Chemung fauna to appear in its meridian; but it is separated from the Genesee slate below by over a thousand feet of deposits of the Portage age, mostly barren shales.

The rocks of Lime Creek, near Rockford, Iowa, as before mentioned, are referred by Professor Hall to the Chemung group, while the western geologists refer them either to the Hamilton group, or to the Kinderhook group which is placed at the base of the Lower Carboniferous. The fauna of these Lime Creek beds has not been met, in its entirety, in any other exposure in the west, but several of its characteristic species appear in the Kinderhook group of Missouri, Indiana and Illinois. The fauna at Ithaca, with which these rare forms are associated, is what is known as the Ithaca fauna, and differs somewhat from the more common and upper fauna of the Chemung group.

Its more common species are:

*Strophodonta mucronata,*
*Spirifer mesocostalis,*
*Spirifer mesostrialis,*
*Productella speciosa,*
*Rhynchonella eximia,*
*Cryptonella eudora,*
*Orthis impressa.*

The stragglers of the western fauna are rare in these beds, and have been seen in only a few exposures.

In the High-point beds this western fauna appears with scarcely any admixture of typical Chemung species.

The species are as distinct from the ordinary Chemung species of New York as they are from those of the Hamilton group below. Moreover, the High-point fauna contains representatives of nearly every species of mollusca known to be common to the several different exposures of the Kinderhook group in the west.

The corals are not so well represented in the east. A few are seen at the High-point locality, and at Ithaca two specimens have been found which agree, so far as their characters are evident, with *Zaphrentis solida* H. Hall and Whitfield's *Fistulipora occidens* is found in all three localities. It is difficult to explain the numerous coincidences in these three faunas otherwise than by considering them geographical extensions of a single fauna.

The facts of the greater predominance of the Kinderhook fauna in the west and of the Chemung fauna in the east, of the blending of the two in the same strata at Ithaca, of the appearance, at High-point, of the western fauna, nearly distinct, but in a stratum in the midst of typical Portage and Chemung rocks, and of the total absence of the western fauna from most of the Chemung rocks of New York, all tend to the conclusion that the Kinderhook group records a fauna whose geographical center was in the mid-continental area, while the typical fauna of the Chemung group had its geographical center as far east as the Appalachian region. In at least a part of the time when these faunas lived they encroached upon each other.

The rocks at the base of the Chemung group in central New York contain also traces of a recurrent Hamilton fauna, as was shown by the author in 1881 (see Proc. A. A. A. S., vol. xxx). And the species found in this recurrent fauna are mostly among those having a wide geographical range in the Hamilton period. There are also a few forms which began in the lower or middle Devonian, and continued to appear among the species of the Chemung group in New York, in some cases the identical species, in others by varieties of the type.

In the latter case we observe that those modifications which mark the western types of the Hamilton group, as distinguished from the New York Hamilton, are the very peculiarities to distinguish the higher Chemung representatives in New York.

The coarse variety of *Atrypa reticularis*, called *A. aspera* var. *occidentalis* Hall, is a case in point. This and the form called *A. spinosa* are the common forms of the upper Chemung.

*Cyrtina Hamiltonensis* appears in the western and northwestern Hamilton as a large, coarse form, and with the same modification in the Chemung. Of the *Orthids*, the wider and more gibbous *Orthis impressa*, called *O. Iowensis* in the west, is typical of the Chemung group, and is the western variety.

*Strophodonta perplana*, var. *nervosa*, and *Strophodonta mucronata* of the Chemung group are much nearer the western *Strophodonta perplana* than the eastern variety of the Hamilton period, and the variety called *Str. canace* of Iowa, in the higher beds, itself appears in the High-point beds of the Chemung.

The common *Str. Cayuta* of the upper Chemung, although quite distinct from the *Str. inæquistriata* of the Hamilton, is apparently only a variety of the western *Str. arcuata*. A like fact may be seen among the Spirifers of the *Sp. mucronatus* type.

The Chemung *Sp. mesocostalis* is easily distinguished from any New York varieties of *Sp. mucronatus*. But the forms met with in the Iowa Hamilton, such as *Sp. submucronatus*, *Sp. bimesialis* and *Sp. inutilis* are intermediate, and approach, at least in the first two "species," the *mesocostalis* type. I also believe that the facts will warrant the generalization that the characteristic species of the Chemung fauna are no more strongly represented in the west than the characteristic Hamilton species are represented in the Chemung rocks of New York.

In New York State the characteristic Chemung fauna appears earliest in the more eastern beds, while in the western part of the State it is only in the middle and upper beds that the fossils appear. These facts suggest the hypothesis that the Chemung fauna came in from the east, and that only the more cosmopolitan forms extended as far west as the mid-continental area; also (2) that the Hamilton fauna had normally a much wider range westward, and (3) was more closely related to the Kinderhook of the west than to the Chemung group of New York.

Finally, I conclude from the study of these several faunas that the deposits of Lime Creek, Rockford, Iowa, and inferentially, all the other beds of the west having a similar fauna, and referred to the Kinderhook group of Meek and Worthen, are geological equivalents of the Chemung period deposits of the east, and not of any eastern lower Carboniferous beds.

This view is in agreement with the original opinions of Professors Hall and Swallow, who referred the Rockford, Iowa, beds and the Chouteau limestone of Missouri to the Chemung period.

There are other reasons, which I cannot here array, for regarding the Rockford, Indiana, Goniatite beds as equivalents of a concretionary limestone of still lower position, in the Portage of New York. To carry the comparison across the ocean, the true equivalents will probably be found in the Pilton and Marwood beds of Devon. While the Genesee slates, passing gradually into the Portage, as they do in Ontario county, New York, with its hard concretionary, calcareous layer, filled with Goniatites, and its *Colcolus aciculum* and *C. tenuicinctum*,

and the characteristic *Cardiola speciosa*, could scarcely be more perfectly represented than by the Domanik schists of Ukta, Russia, with their 'Kalknieren' and the 'Goniatiten Schiefer' of Büdesheim in the Eifel. Their 'Black shales saturated with naphtha,' the 'calcareous concretion,' the 'Goniatites' (the species are closely comparable), the 'slender Orthoceratites,' and the '*Cardium palmatum*' of Goldfuss= *Cardiola retrostriata* Keyserling (the figures of which in Keyserling, Beob., p. 254, t. in fig. 3, or as figured by Roemer, 1876, Taf. 35, fig. 16 *a*, *b*, *c*, *d*, are among the most perfect illustrations I have seen of the common Portage *Cardiola*), and these all leave little doubt as to the close equivalency of the several deposits.

From the above facts it appears reasonable to infer that the Kinderhook group, well developed in the interior of the continent, is represented by a thin wedge at the base of the Chemung period of New York; that the upper Chemung fauna probably did not extend far west of New York State, but if it does appear farther west, it should be looked for in the upper part of, or above the Kinderhook group. So long as the Chemung group is to be retained in the Devonian system, the beds of Lime Creek, Iowa, and their equivalents should be called Devonian. How much of the so-called Kinderhook group this will include must be determined by future investigation. But there can no longer be doubt that there are beds in the interior continental area which are geologically the equivalents of the Chemung period of New York.

---

## Art. IX.—*Contributions to the Geological Chemistry of Yellowstone National Park.*

### I. *Geyser waters and deposits;* by Henry Leffmann, M.D.

The specimens from which the following analyses were made were collected by Dr. A. C. Peale in 1878. Most of the geysers and hot springs are siliceous and produce deposits which vary from hyalite to chalcedony according to age. In most of the waters examined the silica is in the free condition and has been so expressed. All the results are given in grains to the Imperial gallon.

1. *Pearl Geyser.*

| | |
|---|---|
| Calcium sulphate | 1·400 |
| Sodium sulphate | 1·890 |
| Sodium chloride | 61·390 |
| Silica | 7·840 |
| | 72·520 |

At the bottom of the bottle containing this water was a quantity of gelatinous matter looking very much like white of egg. Under the microscope it was entirely structureless, and by heat it dried up to a white opaque mass. Only a small quantity was available for analysis. This was collected on a filter, washed well with distilled water, and then allowed to remain for several weeks in a closed vessel with strong sulphuric acid. It shrank to about one-tenth its volume and became white. It was weighed, heated to redness, weighed again, and then the silica determined by fusion as usual. The results were

| | | |
|---|---|---|
| Weight before heating | ·163 gram. | |
| Weight after heating | ·155 gram = water | 4·9% |
| Silica | ·129 gram = | 79·1% |

Traces of $Al_2O_3$, $Fe_2O_3$ and CaO.

The deposit is probably gelatinous silica mixed with some impurities.

2. *Jug Spring.*

| | |
|---|---|
| Calcium carbonate | 0·791 |
| Sodium carbonate | 49·140 |
| Sodium sulphate | 2·121 |
| Sodium chloride | 31·570 |
| Silica | 14·560 |
| | 98·182 |

3. *Opal Spring.*—This is not a geyser but a spring having the temperature of 90° F. The water is opalescent; its appearance is exactly like that which is produced by adding an alcoholic solution of rosin to a large volume of water. The opalescence remains for months, even though the water is kept perfectly quiet. On evaporating the water it gelatinizes markedly before it becomes entirely dry.

| | |
|---|---|
| Sodium chloride | 72·180 |
| Calcium sulphate | 3·220 |
| Calcium chloride | 4·060 |
| Silica | 53·760 |
| | 143·220 |

4. *Deposit from Bronze Spring, Shoshone Geyser Basin.*—This deposit is in convoluted layers with bronze-colored surfaces. The powder is fawn-colored. Hardness 5·5.

| | |
|---|---|
| Silica | 83·1 |
| Iron oxide and alumina | 1·2 |
| Organic matter and water | 13·6 |

On heating the powder in the drying oven it loses five (5) per cent; a high heat causes it to turn gray, and give out a distinct odor of nitrogenous organic matter. The iron oxide and alumina appear to be in union with the organic matter.

## II. *Rocks of the Park;* by Wm. Beam.

The following specimens are from collections made in 1878 by Messrs. Peale and Holmes, geologists to the Hayden Survey. All the rocks so far examined are evidently of igneous origin, and, except the first, are trachytic.

1. *Porphyritic obsidian.*—From the divide between Yellowstone Lake and Upper Geyser Basin of Fire Hole River. Hardness, 6; sp. gr., 2·4. Fracture conchoidal, splintery. Color, greenish black, semi-transparent. Fusibility 4. When heated strongly, swells up to a white blebby mass. With borax on platinum wire, dissolves in large quantity to a clear glass. With microcosmic salt, leaves a skeleton of silica.

Analysis:

| | |
|---|---|
| $SiO_2$ | 77·00% |
| $Al_2O_3 + Fe_2O_3$* | 13·40 |
| $CaO$ | 1·25 |
| $MgO$ | 1·19 |
| $Na_2O$ | 3·43 |
| $K_2O$ | 3·62 |
| $H_2O$ (by ignition) | ·70 |
| | 100·59 |

2. *Pebble of quartz trachyte covered with a deposit from Echinus Geyser.*—Pebble about one and a half inches in diameter, light fawn in color, and containing small masses of transparent colorless silica. Hardness, 3·5; sp. gr., 2·6. Nearly infusible. Turns white when strongly heated. Gives with borax a clear bead, and with microcosmic salt leaves a skeleton of silica. The powdered mineral is slightly acted upon by hydrochloric acid, and the filtered liquid does not contain any sulphates.

The analysis gave:

| | |
|---|---|
| $SiO_2$ | 77·90 |
| $Al_2O_3 + Fe_2O_3$* | 14·55 |
| $CaO$ | ·40 |
| $MgO$ | trace |
| $K_2O$ | 4·63 |
| $Na_2O$ | 2·10 |
| $H_2O$ (by ignition) | 1·00 |
| | 100·58 |

* Very little $Fe_2O_3$.

Other specimens are being examined and will be reported upon soon.

715 Walnut street, Philadelphia.

ART. X. — *Notes on the Electromagnetic Theory of Light;* by J. WILLARD GIBBS. No. III. *On the General Equations of Monochromatic Light in Media of every degree of Transparency.*

1. THE last April and June numbers of this Journal* contain an investigation of the velocity of plain waves of light, in which they are regarded as consisting of solenoidal electrical fluxes in an indefinitely extended medium of uniform and very fine-grained structure. It was also supposed that the medium was perfectly transparent, although without discussion of the physical properties on which transparency depends, and that the electrical motions were not complicated by any distinctively magnetic phenomena.

In the present paper† the subject will be treated with more generality, so as to obtain the general equations of monochromatic light for media of every degree of transparency, whether sensibly homogeneous or otherwise, which have a very fine-grained molecular structure as measured by a wave-length of light. There will be no restriction with respect to magnetic influence, except that an oscillating magnetization of the medium will be excluded.‡

In order to conform as much as possible to the ordinary view of electrical phenomena,§ we shall not introduce at first

* See volume xxiii of this Journal, pages 262–275, and 460–476.

† This paper contains, with some additional developments, the substance of a communication to the National Academy of Sciences in November, 1882.

‡ Where a body capable of magnetization is subjected to the influence of light, (as when light is reflected from the surface of iron,) there are two simple hypotheses which present themselves with respect to the magnetic state of the body. One is that the magnetic forces due to the light are not of sufficient duration to allow the molecular changes which constitute magnetization to take place to any sensible extent. The other is that the magnetization has a constant ratio to the magnetic force without regard to its duration. We might easily make a more general hypothesis which would embrace both of those mentioned as extreme cases, and which would be irreproachable from a theoretical stand-point; but it would complicate our equations to a degree which would not be compensated by their greater generality, since no phenomena depending on such magnetization have been observed, so far as the writer is aware, or are likely to be, except in a very limited class of cases.

For the purposes of this paper, therefore, it has seemed better to exclude media capable of magnetization, except so far as the first mentioned hypothesis may be applicable. But it does not appear that this requires us to exclude cases in which the medium is subject to the influence of a permanent magnetic force, such as produces the phenomenon of the magnetic rotation of the plane of polarization.

§ It has, perhaps, retarded the acceptance of the electromagnetic theory of light that it was presented in connection with a theory of electrical action, which is probably more difficult to prove or disprove, and certainly presents more difficulties of comprehension, than the connection of optical and electrical phenomena, and which, as resting largely on *a priori* considerations, must naturally appear very differently to different minds. Moreover, the mathematical method by which the subject was treated, while it will remain a striking monument of its author's originality of thought, and profoundly modify the development of mathe-

the hypothesis of Maxwell that electrical fluxes are solenoidal.* Our results, however, will be such as to require us to admit the substantial truth of this hypothesis, if we regard the processes involved in the transmission of light as electrical.

With regard to the undetermined questions of electrodynamic induction, we shall adopt provisionally that hypothesis which appears the most simple, yet proceed in such a manner that it will be evident exactly how our results must be altered, if we prefer any other hypothesis.

Electrical quantities will be treated as measured in electromagnetic units.

2. We must distinguish, as before, between the *actual* electrical displacements, which are too complicated to follow in detail with analysis, and which in their minutiæ elude experimental demonstration, and the displacements as *averaged* for spaces which are large enough to smooth out their minor irregularities, but not so large as to obliterate to any sensible extent those more regular features of the electrical motion, which form the subject of optical experiment. These spaces must therefore be large as measured by the least distances between molecules, but small as measured by a wave-length of light. We shall also have occasion to consider similar averages for other quantities, as electromotive force, the electrostatic potential, etc. It will be convenient to suppose that the space for which the average is taken is the same in all parts of the field,† say a sphere of uniform radius having its center at the point considered.

Whatever may be the quantities considered, such averages will be represented by the notation

$$[\quad]_{\text{Ave}}$$

If, then, $\xi$, $\eta$, $\zeta$ denote the components of the actual displacement at the point considered,

$$[\xi]_{\text{Ave}}, \qquad [\eta]_{\text{Ave}}, \qquad [\zeta]_{\text{Ave}}$$

will represent the average values of these components in the small sphere about that point. These average values we shall

matical physics, must nevertheless, by its wide departure from ordinary methods, have tended to repel such as might not make it a matter of serious study.

*A flux is said to be *solenoidal* when it satisfies the conditions which characterize the motion of an incompressible fluid,—in other words, if $u$, $v$, $w$ are the rectangular components of the flux, when

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0,$$

and the normal component of the flux is the same on both sides of any surfaces of discontinuity which may exist.

† This is rather to fix our ideas, than on account of any mathematical necessity. For the space for which the average is taken may in general be considerably varied without sensibly affecting the value of the average.

treat as functions of the coördinates of the center of the sphere and of the time, and may call them, for brevity, the *average values* of $\xi, \eta, \zeta$. But however they may be designated, it is essential to remember that it is a space-average for a certain very small space, and never a time-average, that is intended.

The object of this paper will be accomplished when we have expressed (explicitly or implicitly), the relations which subsist between the values of $[\xi]_{\text{Ave}}$, $[\eta]_{\text{Ave}}$, $[\zeta]_{\text{Ave}}$, at different times and in different parts of the field,—in other words, when we have found the conditions which these quantities must satisfy as functions of the time and the coördinates.

3. Let us suppose that luminous vibrations of any one period* are somewhere excited, and that the disturbance is propagated through the medium. The motions which are excited in any part of the medium, and the forces by which they are kept up, will be expressed by harmonic functions of the time, having the same period,† as may be proved by the single principle of the superposition of motions, quite independently of any theory of the constitution of the medium, or of the nature of the motions, as electrical or otherwise. This is equally true of the actual motions, and of the averages which we are to consider. We may therefore set

$$\left.\begin{aligned}[\xi]_{\text{Ave}} &= a_1 \cos\frac{2\pi}{p}t + a_2 \sin\frac{2\pi}{p}t,\\ &\text{etc.,}\end{aligned}\right\} \qquad (1)$$

where $t$ denotes the time, $p$ the period, and $a_1$, $a_2$, functions of the coördinates. It follows that

$$\left.\begin{aligned}[\ddot{\xi}]_{\text{Ave}} &= -\frac{4\pi^2}{p^2}[\xi]_{\text{Ave}},\\ &\text{etc.}\end{aligned}\right\} \qquad (2)$$

* There is no real loss of generality in making the light monochromatic, since in every case it may be divided into parts, which are separately propagated, and each of which is monochromatic to any required degree of approximation.

† It is of course possible that the expressions for the forces and displacements should have constant terms. But these will disappear, if the displacements are measured from the state of equilibrium about which the system vibrates, and we leave out of account in measuring the forces (and the electrostatic potential) that which would belong to the system in the state of equilibrium. To prevent misapprehension, it should be added that the term *electrical displacement* is *not* used in the restricted sense of *dielectric displacement* or *polarization*. The variation of the electrical displacement, as the term is used in this paper, constitutes what Maxwell calls the total motion of electricity or true current, and what he divides into two parts, which he distinguishes as the current of conduction and the variation of the electrical displacement. Such a division of the total motion of electricity is not necessary for the purposes of this paper, and the term displacement is used with reference to the total motion of electricity in a manner entirely analogous to that in which the term is ordinarily used in the theory of wave-motion.

4. Now, on the electrical theory, these motions are excited by electrical forces, which are of two kinds, distinguished as electrostatic and electrodynamic. The electrostatic force is determined by the electrostatic potential. If we write $q$ for the actual value of the potential, and $[q]_{\text{Ave}}$ for its value as averaged in the manner specified above, the components of the actual electrostatic force will be

$$-\frac{dq}{dx}, \qquad -\frac{dq}{dy}, \qquad -\frac{dq}{dz};$$

and for the average values of these components in the small spaces described above we may write

$$-\frac{d[q]_{\text{Ave}}}{dx}, \qquad -\frac{d[q]_{\text{Ave}}}{dy}, \qquad -\frac{d[q]_{\text{Ave}}}{dz},$$

for it will make no difference whether we take the average before or after differentiation.

5. The electrodynamic force is determined by the acceleration of electrical flux in all parts of the field, but physicists are not entirely agreed in regard to the laws by which it is determined. This difference of opinion is however of less importance, since it will not affect the result if electrical fluxes are always solenoidal. According to the most simple law, the components of the force are given by the volume-integrals

$$-\iiint \frac{\ddot{\xi}}{r}\,dv, \qquad -\iiint \frac{\ddot{\eta}}{r}\,dv, \qquad -\iiint \frac{\ddot{\zeta}}{r}\,dv,$$

where $dv$ represents an element of volume, and $r$ the distance of this element from the point for which the value of the electromotive force is to be determined. In other words, the components of the force at any point are determined from the components of acceleration in all parts of the field by the same process by which (in the theories of gravitation, etc.,) the value of the potential at any point is determined from the density of matter in all parts of space, except that the sign is to be reversed. Adopting this law provisionally, at least, we may express it by saying that the components of electrodynamic force are equal to the potentials taken negatively of the components of acceleration of electrical flux. And we may write, for brevity,

$$-\text{Pot}\,\ddot{\xi}, \qquad -\text{Pot}\,\ddot{\eta}, \qquad -\text{Pot}\,\ddot{\zeta},$$

for the components of force, using the symbol *Pot* to denote the operation by which the potential of a mass is derived from its density. For the average values of these components in the small spaces defined above, we may write

$$-\text{Pot}\,[\ddot{\xi}]_{\text{Ave}}, \qquad -\text{Pot}\,[\ddot{\eta}]_{\text{Ave}}, \qquad -\text{Pot}\,[\ddot{\zeta}]_{\text{Ave}}$$

since it will make no difference whether we take the average before or after the operation of taking the potential.

6. If we write X, Y, Z for the components of the total electromotive force (electrostatic and electrodynamic), we have

$$\left.\begin{aligned}[X]_{\text{Ave}} &= -\operatorname{Pot}[\ddot{\xi}]_{\text{Ave}} - \frac{d[q]_{\text{Ave}}}{dx},\\ &\text{etc.};\end{aligned}\right\} \tag{3}$$

or by (2)

$$\left.\begin{aligned}[X]_{\text{Ave}} &= \frac{4\pi^2}{p^2}\operatorname{Pot}[\xi]_{\text{Ave}} - \frac{d[q]_{\text{Ave}}}{dx},\\ &\text{etc.}\end{aligned}\right\} \tag{4}$$

It will be convenient to represent these relations by a vector notation. If we represent the displacement by $\mathsf{U}$, and the electromotive force by $\mathsf{E}$, the three equations of (3) will be represented by the single vector equation

$$[\mathsf{E}]_{\text{Ave}} = -\operatorname{Pot}[\ddot{\mathsf{U}}]_{\text{Ave}} - \nabla[q]_{\text{Ave}}, \tag{5}$$

and the three equations of (4) by the single vector equation

$$[\mathsf{E}]_{\text{Ave}} = \frac{4\pi^2}{p^2}\operatorname{Pot}[\mathsf{U}]_{\text{Ave}} - \nabla[q]_{\text{Ave}}, \tag{6}$$

where, in accordance with quaternionic usage, $\nabla[q]_{\text{Ave}}$ represents the vector which has for components the derivatives of $[q]_{\text{Ave}}$ with respect to rectangular coördinates. The symbol *Pot* in such a vector equation signifies that the operation which is denoted by this symbol in a scalar equation is to be performed upon each of the components of the vector.

7. We may here observe that if we are not satisfied with the law adopted for the determination of electrodynamic force, we have only to substitute for $-Pot$ in these vector equations, and in those which follow, the symbol for the operation, whatever it may be, by which we calculate the electrodynamic force from the acceleration.* For the operation must be of such a character, that if the acceleration consist of any number of parts, the force due to the whole acceleration will be the resultant of the forces due to the separate parts. It will evidently make no difference whether we take an average before or after such an operation.

8. Let us now examine the relation which subsists between the values of $[\mathsf{E}]_{\text{Ave}}$ and $[\mathsf{U}]_{\text{Ave}}$ for the same point, that is, between the average electromotive force and the average displacement in a small sphere with its center at the point consid-

*The same would not be true of the corresponding scalar equations, (3) and (4). For one component of the force might depend upon all the components of acceleration. Such is in fact the case with the law of electromotive force proposed by Weber.

ered. We have already seen that the forces and the displacements are harmonic functions of the time having a common period.

A little consideration will show that if the average electromotive force in the sphere is given as a function of the time, the displacements in the sphere, both average and actual, must be entirely determined. Especially will this be evident, if we consider that since we have made the radius of the sphere very small in comparison with a wave-length, the average force must have sensibly the same value throughout the sphere, (that is, if we vary the position of the center of the sphere for which the average is taken by a distance not greater than the radius, the value of the average will not be sensibly affected,) and that the difference of the actual and average force at any point is entirely determined by the motions in the immediate vicinity of that point. If, then, certain oscillatory motions may be kept up in the sphere under the influence of electrostatic and electrodynamic forces due to the motion in the whole field, and if we suppose the motions in and very near that sphere to be unchanged, but the motions in the remoter parts of the field to be altered, only not so as to affect the average resultant of electromotive force in the sphere, the actual resultant of electromotive force will also be unchanged throughout the sphere, and therefore the motions in the sphere will still be such as correspond to the forces.

Now the average displacement is a harmonic function of the time having a period which we suppose given. It is therefore entirely determined for the whole time the vibrations continue by the values of the six quantities

$$[\xi]_{\text{Ave}},\quad [\eta]_{\text{Ave}},\quad [\zeta]_{\text{Ave}},\quad [\dot{\xi}]_{\text{Ave}},\quad [\dot{\eta}]_{\text{Ave}},\quad [\dot{\zeta}]_{\text{Ave}}$$

at any one instant. For the same reason the average electromotive force is entirely determined for the whole time by the values of the six quantities

$$[X]_{\text{Ave}},\quad [Y]_{\text{Ave}},\quad [Z]_{\text{Ave}},\quad [\dot{X}]_{\text{Ave}},\quad [\dot{Y}]_{\text{Ave}},\quad [\dot{Z}]_{\text{Ave}}$$

for the same instant. The first six quantities will therefore be functions of the second, and the principle of the superposition of motions requires that they shall be homogeneous functions of the first degree. And the second six quantities will be homogeneous functions of the first degree of the first six. The coefficients by which these functions are expressed will depend upon the nature of the medium in the vicinity of the point considered. They will also depend upon the period of vibration, that is, upon the color of the light.*

* The relations between the displacements in one of the small spaces considered and the average electromotive force is mathematically analogous to the relation between the displacements in a system of a high degree of complexity and certain forces exerted from without, which are harmonic functions of the time and under

We may therefore write in vector notation

$$[\mathsf{E}]_{\text{Ave}} = \Phi[\mathsf{U}]_{\text{Ave}} + \Psi[\dot{\mathsf{U}}]_{\text{Ave}} \qquad (7)$$

where $\Phi$ and $\Psi$ denote linear functions.*

The optical properties of media are determined by the form of these functions. But all forms of linear functions would not be consistent with the principle of the conservation of energy.

In media which are more or less opaque, and which therefore absorb energy, $\Psi$ must be of such a form that the function always makes an acute angle (or none) with the independent variable. In perfectly transparent media $\Psi$ must vanish, unless the function is at right angles to the independent variable. So far as is known, the last occurs only when the medium is subject to magnetic influence. In perfectly transparent media, the principle of the conservation of energy requires that $\Phi$ should be self-conjugate, *i. e.*, that for three directions at right angles to one another, the function and independent variable should coincide in direction.

In all isotropic media not subject to magnetic influence, it is probable that $\Phi$ and $\Psi$ reduce to numerical coefficients, as is certainly the case with $\Phi$ for transparent isotropic media.

9. Comparing the two values of $[\mathsf{E}]_{\text{Ave}}$, we have

$$\frac{4\pi^2}{p^2}\,\text{Pot}\,[\mathsf{U}]_{\text{Ave}} - \nabla[q]_{\text{Ave}} = \Phi[\mathsf{U}]_{\text{Ave}} + \Psi[\dot{\mathsf{U}}]_{\text{Ave}}. \qquad (8)$$

This equation, in connection with that by which we express the solenoidal character of the displacements, if we regard them as necessarily solenoidal, or in connection with that which expresses the relation between the electrostatic potential and the displacements, if we reject the solenoidal hypothesis, may be regarded as the general equation of the vibrations of monochromatic light, considered as oscillating electrical fluxes. For the symbol *Pot*, however, we must substitute the symbol representing the operation by which electromotive force is calculated from acceleration of flux, with the negative sign, if we are not satisfied with the law provisionally adopted.

It is important to observe that the existence of molecular vibrations of ponderable matter, due to the passage of light through the medium, will not affect the reasoning by which this equation has been established, provided that the nature

the influence of which the system vibrates. The ratio of the displacements to the forces will in general vary with the period, and may vary very rapidly.

An example in which these functions vary very rapidly with the period is afforded by the phenomena of selective absorption and abnormal dispersion.

* A vector is said to be a linear function of another, when the three component of the first are homogeneous functions of the first degree of the three component of the second.

and intensity of these vibrations in any small part of the medium (as measured by a wave-length) are entirely determined by the electrical forces and motions in that part of the medium. But the equation would not hold in case of molecular vibrations due to magnetic force. Such vibrations would constitute an oscillating magnetization of the medium, which has already been excluded from the discussion.

The supposition which has sometimes been made,* that electricity possesses a certain mass or inertia, would not at all affect the validity of the equation.

10. The equation may be reduced to a form in some respects more simple by the use of the so-called imaginary quantities. We shall write $\iota$ for $\sqrt{(-1)}$. If we differentiate with respect to the time, and substitute $-\frac{4\pi^2}{p^2}[\mathsf{U}]_{\text{Ave}}$ for $[\ddot{\mathsf{U}}]_{\text{Ave}}$, we obtain

$$\frac{4\pi^2}{p^2}\,\text{Pot}\,[\dot{\mathsf{U}}]_{\text{Ave}} - \nabla[\dot{q}]_{\text{Ave}} = \Phi[\dot{\mathsf{U}}]_{\text{Ave}} - \frac{4\pi^2}{p^2}\,\Psi[\mathsf{U}]_{\text{Ave}}$$

If we multiply this equation by $\iota$, either alone or in connection with any real factor, and add it to the preceding, we shall obtain an equation which will be equivalent to the two of which it is formed. Multiplying by $-\frac{p\iota}{2\pi}$ and adding, we have

$$\frac{4\pi^2}{p^2}\,\text{Pot}\left([\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}}\right) - \nabla\left([q]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{q}]_{\text{Ave}}\right)$$
$$= \left(\Phi + \iota\frac{2\pi}{p}\,\Psi\right)\left([\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}}\right).$$

If we set

$$\mathsf{W} = [\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}}, \tag{9}$$

$$\mathsf{Q} = [q]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{q}]_{\text{Ave}}, \tag{10}$$

$$\Theta = \Phi + \iota\frac{2\pi}{p}\,\Psi, \tag{11}$$

our equation reduces to

$$\frac{4\pi^2}{p^2}\,\text{Pot}\,\mathsf{W} - \nabla\mathsf{Q} = \Theta\mathsf{W}. \tag{12}$$

In this equation $\theta$ denotes a complex linear vector function, *i. e.*, a vector function of which the X-, Y-, and Z-components are expressed in terms of the X-, Y-, and Z-components of the independent variable by means of coëfficients of the form $a+\iota b$. $\underline{\mathsf{W}}$ is a bi-vector of which the real part represents the

* See Weber, Abhandl. d. K. Sächs. Gesellsch. d. Wiss., vol. vi. p. 593–597; Lorberg, Crelle's Journal, vol. lxi. p. 55.

averaged displacement $[\mathsf{U}]_{\text{Ave}}$, and the coefficient of $\epsilon$ the rate of increase of the same multiplied by a constant factor. This bi-vector therefore represents the average state of a small part of the field both with respect to position and velocity. We may also say that the coefficient of $\epsilon$ in $\mathsf{W}$ represents the value of the averaged displacement $[\mathsf{U}]_{\text{Ave}}$ at a time one-quarter of a vibration earlier than the time principally considered.

11. It may serve to fix our ideas to see how $\mathsf{W}$ is expressed as a function of the time. We may evidently set

$$[\mathsf{U}]_{\text{Ave}} = \mathsf{A}_1 \cos\frac{2\pi}{p}t + \mathsf{A}_2 \sin\frac{2\pi}{p}t$$

where $\mathsf{A}_1$ and $\mathsf{A}_2$ are vectors representing the amplitudes of the two parts into which the vibration is resolved. Then

$$\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}} = -\mathsf{A}_1 \sin\frac{2\pi}{p}t + \mathsf{A}_2 \cos\frac{2\pi}{p}t,$$

and

$$[\mathsf{U}]_{\text{Ave}} - \iota\frac{p}{2\pi}[\dot{\mathsf{U}}]_{\text{Ave}} = (\mathsf{A}_1 - \iota\mathsf{A}_2)\left(\cos\frac{2\pi}{p}t + \iota\sin\frac{2\pi}{p}t\right);$$

that is, if we set $\mathsf{A}=\mathsf{A}_1-\iota\mathsf{A}_2$,

$$\mathsf{W} = \mathsf{A}\, e^{\frac{2\pi\iota t}{p}}. \qquad (13)$$

In like manner we may obtain

$$\mathsf{Q} = g\, e^{\frac{2\pi\iota t}{p}}, \qquad (14)$$

where $g$ is a bi-scalar, or complex quantity of ordinary algebra. Substituting these values in (12), and cancelling the common factor containing the time, we have

$$\frac{4\pi^2}{p^2}\operatorname{Pot}\mathsf{A} - \nabla g = \Theta\mathsf{A}. \qquad (15)$$

Our equation is thus reduced to one between $\mathsf{A}$ and $g$, and may easily be reduced to one in $\mathsf{A}$ alone.* Now $\mathsf{A}$ represents six numerical quantities, (viz: the three components of $\mathsf{A}_1$, and the three of $\mathsf{A}_2$), which may be called the six components of amplitude. The equation, therefore, substantially represents the relations between the six components of amplitude in different parts of the field.† The equation is, however, not really

* The terms $\nabla\mathsf{Q}$, $\nabla q$ are allowed to remain in these equations, because the best manner of eliminating them will depend somewhat upon our admission or rejection of the solenoidal hypothesis.

† The representation of the six components of amplitude by a single letter should not be regarded as an analytical artifice. It only leaves undivided in our notation that which is undivided in the nature of things. The separation of the six components of amplitude is artificial, in that it introduces arbitrary elements into the discussion, viz: the directions of the axes of the coördinates, and the zero of time.

different from (12), since $\mathsf{A}$ and $g$ are only particular values of $\mathsf{W}$ and Q.

12. From the general equation given above (8, 12, or 15), in connection with the solenoidal hypothesis, we may easily derive the laws of the propagation of plane waves in the interior of a sensibly homogeneous medium, and the laws of reflection and refraction at surfaces between such media. This has been done by Maxwell,* Lorentz,† and others,‡ with fundamental equations more or less similar.

The method, however, by which the fundamental equation has been established in this paper seems free from certain objections which have been brought against the ordinary form of the theory. As ordinarily treated, the phenomena are made to depend entirely on the inductive capacity and the conductivity of the medium, in a manner which may be expressed by the equation

$$[\mathsf{U}]_{\text{Ave}} = \left(\frac{\mathsf{K}}{4\pi} - \frac{p^2\mathsf{C}}{4\pi^2}\frac{d}{dt}\right)\left(\frac{4\pi^2}{p^2}\operatorname{Pot}[\mathsf{U}]_{\text{Ave}} - \nabla[q]_{\text{Ave}}\right), \quad (16)$$

which will be equivalent to (12), if

$$\mathsf{W} = \left(\frac{\mathsf{K}}{4\pi} - \iota\frac{p\mathsf{C}}{2\pi}\right)\left(\frac{4\pi^2}{p^2}\operatorname{Pot}\mathsf{W} - \nabla\mathrm{Q}\right), \quad (17)$$

where K and C denote in the most general case the linear vector functions, but in isotropic bodies the numerical coëfficients, which represent inductive capacity and conductivity. By a simple transformation [see (9) and (10)], this equation becomes

$$\theta^{-1} = \frac{\mathsf{K}}{4\pi} - \iota\frac{p\mathsf{C}}{2\pi}, \quad (18)$$

where $\theta^{-1}$ represents the function inverse to $\theta$.

Now, while experiment appears to verify the existence o such a law as is expressed by equation (12), it does not show that $\theta$ has the precise form indicated by equation (16). In other words, experiment does not satisfactorily verify the relations expressed by (16) and (17), if K and C are understood to be the operators (or, in isotropic bodies, the numbers) which represent induction capacity and conductivity in the ordinary sense of the terms.

* Phil. Trans., vol. clv (1865), p. 459, or *Treatise on Electricity and Magnetism*, Chap. XX.

† Schlömilch's Zeitschrift, vol. xxii, pp. 1-30 and 205-219; xxiii, pp. 197-210.

‡ See Fitzgerald, Phil. Trans., vol. clxxi, p. 691; J. J. Thomson, Phil. Mag., V, vol. ix, p. 284; Rayleigh, Phil. Mag., V, vol. xii, p. 81.

That the electromagnetic theory of light gives the conditions relative to the boundary of different media, which are required by the phenomena of reflection and refraction, was first shown by Helmholtz. See Crelle's Journal, vol. lxxii (1870), p. 57.

The discrepancy is most easily shown in the most simple case, when the medium is isotropic and perfectly transparent, and $\theta$ reduces to a numerical quantity. The square of the velocity of plane waves is then equal to $\frac{\Theta}{4\pi}$, and equation (18) would make it independent of the period; that is, would give no dispersion of colors. The case is essentially the same in transparent bodies which are not isotropic.*

The case is worse with metals, which are characterized electrically by great conductivity, and optically by great opacity. In their papers cited above, Lorentz and Rayleigh have observed that the experiments of Jamin on the reflection of light from metallic surfaces would often require, as ordinarily interpreted on the electro-magnetic theory, a negative value for the inductive capacity of the metal. This would imply that the electrical equilibrium in the metal is unstable. The objection, therefore, is essentially the same as that which Lord Rayleigh had previously made to Cauchy's theory of metallic reflection, viz: that the apparent mechanical explanation of the phenomena is illusory, since the numerical values given by experiment as interpreted on Cauchy's theory would involve an unstable equilibrium of the ether in the metal.†

13. All this points to the same conclusion—that the ordinary view of the phenomena is inadequate. The object of this paper will be accomplished, if it has been made clear, how a point of view more in accordance with what we know of the molecular constitution of bodies will give that part of the ordinary theory which is verified by experiment, without including that part which is in opposition to observed facts.‡

* See note to the first paper of Lorentz, cited above, Schlömilch, vol. xxii, p. 23.

† See Phil. Mag., IV, vol. xliii (1872), p. 321.

‡ The consideration of the processes which we may suppose to take place in the smallest parts of a body through which light is transmitted, farther than is necessary to establish the general equation given above, is foreign to the design of this paper. Yet a word may be added with respect to the difficulties signalized in the ordinary form of the theory. The comparatively simple case of a perfectly transparent body has been examined more in detail in one of the papers already cited, where there is given an explanation of the dispersion of colors from the point of view of this paper. It is there shown that the effect of the non-homogenity of the body in its smallest parts is to add a term to the expression for the kinetic energy of electrical waves, which for an isotropic body may be roughly described as similar to that which would be required if the electricity had a certain mass or inertia. (See especially §§ 7, 9 and 12, pages 266 ff. of volume xxiii of this Journal.) The same must be true of media of any degree of opacity. Now the difficulty with the optical properties of the metals is that the real part of $\Theta$ (or $\Theta^{-1}$) is in some cases negative. This implies that at a moment of greatest displacement the electromotive force is in the direction opposite to the displacement, instead of having the same direction, as in transparent isotropic bodies. Now a certain part of the electromotive force must be required to oppose the apparent inertia, and another part to oppose the electrical elasticity of the medium. These parts of the force must have opposite directions. In transparent

While the writer has aimed at a greater degree of rigor than is usual in the establishment of the fundamental equation of monochromatic light, it is not claimed that this equation is absolutely exact. The contrary is evident from the fact that the equation does not embrace the phenomena which characterize such circularly polarizing bodies as quartz. This, however, only implies the neglect of extremely small quantities—very small, for example, as compared with those which determine the dispersion of colors. In one of the papers already cited,* the case of a perfectly transparent body is treated with a higher degree of approximation, so as to embrace the phenomena in question.

---

ART. XI.—*The Rainfall in Middletown, Connecticut, from* 1859 *to* 1882; by HENRY D. A. WARD.

WHEN Mr. B. F. Harrison's paper, on the Rainfall in Wallingford, appeared in the American Journal of Science in June, 1881, a friend suggested that the publication of a similar one from my own records would be of interest as affording a means of comparing the precipitation of the two places.

As a result of this suggestion the following table has been prepared. It covers a period of twenty-four years, from January 1st, 1859 to December 31st, 1882, and, like Mr. Harrison's, gives month by month the amount of rain and melted snow, and the depth of snow. Middletown is in latitude 41° 33′ N. and longitude 72° 39′ W., and is about ten miles northeast of Wallingford, on the eastern declivity of the range of hills on whose western slope that town is situated.

I deem it proper to state that, up to June 1st, 1868, the observations were made by the late Professor Johnston of the Wesleyan University, at an elevation of some 175 feet above sea-level. Since that time they have been made by myself, at a station about a quarter of a mile from Professor Johnston's and 70 feet above sea-level.

bodies the latter part is by far the greater. But it need not surprise us that the former should be the greater in some metals.

It has been remarked by Lorentz that the difficulty with respect to metals would be in a measure relieved if we should suppose electricity to have the property of inertia. (See § 11 of his third paper, Schlömilch's Zeitschrift, vol. xxiii, p. 208.) But a supposition of this kind, taken literally, would involve a dispersion of colors in vacuo, and still be inadequate, as Lorentz remarks, to explain the phenomena observed in metals.

* See volume xxiii of this Journal, page 460.

| | JANUARY. | | FEBRUARY. | | MARCH. | | APRIL. | | MAY. | | JUNE. | JULY. | AUG'ST | SEPT. | OCTOBER. | | NOVEMBER. | | DECEMBER. | | YEAR. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. | Rain. | Rain. | Rain. | Rain. | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. | Rain. | Snow. |
| 1859 | 7·18 | 28·00 | 4·20 | 23·00 | 7·52 | 12·00 | 3·06 | 0·00 | 4·18 | -- | 6·09 | 2·17 | 6·57 | 3·90 | 2·13 | -- | 2·45 | -- | 3·88 | 9 00 | 53·33 | 72·00 |
| 1860 | 1·69 | 10·00 | 2·62 | 18·00 | 1·68 | 0·00 | 1·71 | 3·00 | 3·86 | -- | 3·14 | 2·76 | 3·70 | 3·70 | 2·56 | -- | 4·74 | -- | 5·23 | 11·00 | 37·39 | 42·00 |
| 1861 | 4·13 | 13·00 | 2·68 | 3·00 | 4·22 | 20·00 | 4·97 | 9·00 | 6·82 | -- | 3·65 | 3·54 | 6·09 | 3·88 | 2·20 | -- | 3·28 | 5·00 | 1·57 | 4·00 | 47·03 | 54·00 |
| 1862 | 5·21 | 4·00 | 2·14 | 19·00 | 3·87 | 3·00 | 1·59 | 0·00 | 2·37 | -- | 8·05 | 6·24 | 1·65 | 5·45 | 3·94 | -- | 5·79 | 3·00 | 1·73 | 16·00 | 48·03 | 45·00 |
| 1863 | 4·24 | 4·00 | 5·11 | 17·00 | 4·73 | 20·00 | 4·26 | 2·00 | 1·74 | -- | 1.01 | 11·14 | 4·90 | 1·73 | 3·34 | -- | 5·02 | 0·00 | 5·25 | 11·00 | 52·47 | 54·00 |
| 1864 | 3·07 | 5·00 | 1·40 | 9·50 | 2·06 | 5·00 | 1·82 | 0·00 | 3·82 | -- | 3·00 | 1·68 | 2 92 | 3·45 | 2·66 | -- | 4·13 | 2·00 | 3·99 | 19·00 | 34·00 | 40·50 |
| 1865 | 4·16 | 11·00 | 3·61 | 8·00 | 4·75 | 2·00 | 3·41 | 1·00 | 6·85 | -- | 2·41 | 4·65 | 1·85 | 0·75 | 3·21 | -- | 3·96 | 0·00 | 2·99 | 12·00 | 42·60 | 34·00 |
| 1866 | 1·61 | 16·00 | 5·11 | 0·00 | 2·60 | 0·00 | 2·90 | 0·00 | 5·38 | -- | 3·02 | 4·04 | 4·24 | 6·74 | 2·98 | -- | 4·34 | 0·00 | 3·31 | 10·00 | 46·27 | 26·00 |
| 1867 | 2·41 | 28·00 | 4·34 | 12·00 | 3·51 | 17·50 | 2·44 | 0·00 | 4·53 | -- | 5·39 | 3·31 | 10·22 | 2·83 | 4·12 | -- | 2·75 | 12·00 | 2·49 | 14·00 | 48·34 | 83·50 |
| 1868 | 3·36 | 27·00 | 1·53 | 12·00 | 2·78 | 17·00 | 4·48 | 14·00 | 7·63 | -- | 5·24 | 2·36 | 7·39 | 10·49 | 0·89 | -- | 4·00 | 0·00 | 2·29 | 11·50 | 52·54 | 81·50 |
| 1869 | 3·17 | 7·00 | 5·04 | 15·00 | 7·51 | 7·50 | 1·95 | 0·00 | 6·05 | -- | 5·38 | 2·96 | 2·80 | 3·90 | 15·54 | -- | 3·34 | 1·00 | 6·33 | 13·00 | 63·97 | 43·50 |
| 1870 | 5·72 | 3·00 | 5·45 | 14·00 | 5·97 | 18·00 | 5·32 | 0·00 | 1·74 | -- | 2·73 | 1·42 | 3·29 | 1·33 | 4·23 | -- | 3·08 | 0·00 | 2·30 | 4·00 | 42·58 | 39·00 |
| 1871 | 3·43 | 22·00 | 4·10 | 22·00 | 6·52 | 1·00 | 3·14 | 4·00 | 4·80 | -- | 4·24 | 5·48 | 8·02 | 1·94 | 3·69 | -- | 4·51 | 0·00 | 3·31 | 9·25 | 53·18 | 58·25 |
| 1872 | 2·19 | 1·25 | 2·87 | 12·00 | 4·02 | 12·75 | 1·95 | 0·00 | 3·09 | -- | 4·89 | 5·43 | 5·58 | 4·94 | 2·47 | -- | 5·08 | 6·50 | 4·08 | 28·00 | 46·59 | 60·50 |
| 1873 | 6·79 | 13·00 | 3·03 | 18·00 | 2·95 | 1·00 | 3·16 | 1·00 | 4·25 | -- | 0·46 | 2·09 | 8·31 | 2·37 | 6·18 | -- | 4·29 | 3·00 | 5·06 | 22·25 | 48·94 | 58·25 |
| 1874 | 5·98 | 10·75 | 3·69 | 23·00 | 1·45 | 5·00 | 7·11 | 2·25 | 3·48 | -- | 2·21 | 5·78 | 6·30 | 2·82 | 1·44 | -- | 2·64 | 1·00 | 2·31 | 8·50 | 45·21 | 50·50 |
| 1875 | 2·86 | 11·50 | 4·86 | 9·50 | 5·18 | 31·50 | 3·89 | 16·00 | 1·44 | -- | 3 25 | 2·49 | 5·64 | 1·59 | 4·56 | -- | 5·73 | 0·50 | 1·20 | 1·00 | 42·69 | 70·00 |
| 1876 | 1·45 | 5·00 | 5·11 | 14·00 | 9·49 | 8·00 | 3·71 | 4·00 | 2·87 | 2·00 | 1·89 | 10·20 | 1·23 | 6·04 | 1·16 | 1·00 | 4·05 | 0·50 | 4·21 | 26·75 | 51·41 | 61·25 |
| 1877 | 3·38 | 18·00 | 1·14 | 2·00 | 9·24 | 3·00 | 2·60 | 0·00 | 1·11 | -- | 6·58 | 2·99 | 6·15 | 0·94 | 9·11 | -- | 7·29 | 0·00 | 1·56 | 0·00 | 52·09 | 23·00 |
| 1878 | 5·77 | 11·00 | 5·13 | 2·00 | 2·89 | 0·00 | 4·42 | 0·00 | 2·93 | -- | 3·68 | 1·99 | 4·89 | 1·80 | 2·74 | -- | 5·48 | 0·50 | 7·91 | 6·50 | 49·63 | 20·00 |
| 1879 | 2·49 | 17·50 | 4·07 | 15·00 | 5·53 | 10·50 | 5·95 | 2·75 | 2·69 | -- | 4·38 | 5·88 | 8·24 | 1·88 | 1·18 | -- | 1·78 | 1·00 | 3·84 | 8·25 | 47·91 | 55·00 |
| 1880 | 3·50 | 5·00 | 3·68 | 8·50 | 3·51 | 10·50 | 3·80 | 0·00 | 0·74 | -- | 3·07 | 5·67 | 5·56 | 4·13 | 3·94 | -- | 2·28 | 1·00 | 2·92 | 18·00 | 42·80 | 43·00 |
| 1881 | 5·17 | 17·00 | 6·15 | 11·00 | 6·42 | 4·00 | 1·74 | 2·00 | 4·57 | -- | 3·55 | 2·84 | 2·87 | 0·49 | 2·41 | -- | 4·50 | 1·00 | 4·19 | 1·50 | 44·90 | 36·50 |
| 1882 | 5·12 | 27·00 | 4·74 | 22·00 | 3·64 | 2·00 | 1·48 | 1·00 | 4·38 | -- | 1·96 | 2·17 | 1·25 | 11·64 | 4·69 | -- | 1·65 | 16·00 | 2·65 | 8·50 | 45·37 | 76·50 |
| Tot'l | 94·08 | 315·00 | 91 80 | 309·50 | 112·04 | 211·25 | 80·86 | 62·00 | 91·32 | 2·00 | 89·27 | 99·28 | 119·66 | 88·73 | 91·37 | 1·00 | 96·16 | 54·00 | 84·70 | 273·00 | 1139·27 | 1227·75 |
| Ave. | 3·920 | 13·125 | 3·825 | 12·896 | 4·668 | 8·802 | 3·369 | 2·583 | 3·805 | 0·083 | 3·719 | 4·136 | 4·986 | 3·697 | 3·807 | 0·041 | 4·006 | 2·250 | 3·529 | 11·375 | 47·47 | 51·16 |

ART. XII.—*New Discoveries in Devonian Crustacea;* by JOHN M. CLARKE.

IN continuation of the notice of some new Devonian Crustacea which was published in this Journal for June, 1882 (3d ser., vol. xxiii, p. 476), I have to add a description of some new and extremely interesting forms allied to those there noticed, with a few remarks on their affinities and distribution. The species there described as *Spathiocaris Emersonii* appears on more careful investigation to have an unusual and remarkable vertical range through the rocks of the Chemung Period. The original examples were found in considerable abundance in the Portage shales, in the town of Naples, Ontario Co., N. Y., but at the time of description were confined, as far as my knowledge went, almost exclusively to one stratum, 550 feet above the top of the "Transition shales,"* between the Genesee and Portage.

My companion in the field, Mr. D. D. Luther, and myself have, during the past summer, found the fossil with the following distribution:

1. In the "Lower Black Band" of the Portage, 50 feet above the "Transition shales," Bristol, Ontario Co.
2. About 150 feet above the "Transition shales," in the town of Naples.
3. Approximately the same horizon in the town of Richmond, Ontario Co.
4. In the "Upper Black Band" of the Portage, 540 feet above the "Transition shales," Naples.
5. In approximately the same horizon, in the "Upper Black Band," 1½ miles south of the Shaker Settlement, along Cashaqua Creek, Livingston Co.
6. In approximately the same horizon in a cut on the Delaware, Lackawanna & Western R. R., in the town of Sparta, Livingston Co.
7. In the shales immediately overlying 4.
8. In the Upper Portage sandstones, Portageville, Wyoming County.

* The term "Transition shales" is applied without liability to misinterpretation to passage beds of slightly arenaceous shales lying between the highest horizon of the fossils belonging distinctively to the Genesee, and the lowest stratum of undoubted Portage age. These beds measure usually between 30 and 60 feet and have a wide distribution in the counties of Ontario, Yates, Livingston, and I believe them to be well defined on the Genesee River at Mt. Morris. They contain a fauna which is a commingling of these fossils: *Cardiola speciosa* H., a lamellibranch diagnostic of the Portage, *Lunulacardium fragile* H., equally diagnostic of the Genesee, with *Coleolus aciculum* H., of the Portage, *Goniatites complanatus* H., of the Hamilton and Portage, *Styliola fissurella* H., abundant from the base of the Hamilton to the base of the Chemung proper, and a *Pleurotomaria* of undescribed species, abundant in the Portage.

9. In the lowest stratum of the Chemung proper, Naples.

10. In the sandstones of the Lower Chemung in the town of Canadice, Ontario Co.

This very wide range of *Spathiocaris Emersonii* without specific variation is the more remarkable on account of the complete differences in the character of the faunæ of which it makes a part in the different strata. In the lower muddy shales, its associates are the more commonly occurring fossils of the Portage rocks, *Goniatites complanatus* H., *Coleolus aciculum* H., *Cardiola speciosa* H., *Lunulacardium ornatum* H., *Cardiomorpha* (*Paracyclas*) *suborbicularis* H. In the bituminous shales of the "Upper Black Band," it appears with remains of the genus *Paleoniscus* and other undetermined fish relics, and also with an abundance of plant remains of doubtful affinities, spores of ferns or Lycopods, and with "Conodonts" and Annelidan teeth; in the Chemung in the lowest horizon with *Leiorhynchus mesacostalis* Hall, and in the upper only with crustacean forms allied to itself, presently to be described. Such a capability of adaptation to environments so markedly different, a muddy or a sandy sea-bottom, or an in-shore, brackish water swamp, such as might have produced the bituminous shales, or if we accept Newberry's suggestion a deep-water, sub-sargossan bottom, and all this without any apparent specific variation, is highly interesting, for in the modern allies of these Crustacea we find a very marked susceptibility to such changes.

I have in my possession a number of fragmentary and ill-defined crustacean remains from the same beds with these fossils, some of which have more or less resemblance to, and may prove to be, abdominal segments, but I should hesitate to describe any as such.

I have discovered another variation from the type of *Spathiocaris* in certain specimens taken from the shales and sandstones of the Chemung proper, at several localities, and in one, Canadice, Ontario Co., associated with *Spathiocaris Emersonii*, with which it is allied in some points of the structure of the carapace. The differences are, however, very strongly defined and generic, as will be readily seen from this diagnosis of the genus.

DIPTEROCARIS (*δίπτερος*=two-winged, *χαρίς*= a prawn).

Carapace in one piece, elongate, divided along the major axis into two more or less separated wings or *alæ*. Greatest width anteriorly through the apex or area of union of the *alæ* of the carapace. These *alæ* approach each other in planes which, normally, make an angle of about 120°, but the area of union is not acute but rounded. *Alæ* united medially for a distance equal to $\frac{1}{3}$d or $\frac{1}{4}$th the length of the carapace, in this union the *alæ* anchylosed and without hingement of any kind. Clefts

extend anteriorly and posteriorly from the ends of the area of union, the anterior cleft being the shorter and its sides making the larger re-entrant angle. The surface of the carapace is marked with fine concentric ridges, as in *Spathiocaris* but is without the radiating lines of that genus.

Of this genus I find three species, as follows:

### Dipterocaris pennæ-Dædali.

Area of union of the sides of the test, or *alæ*, extends about $\frac{1}{5}$th the entire length of the carapace and is situated anteriorly. The antennal or cephalic cleft is $\frac{1}{3}$d the length of the carapace, its sides generally straight, somewhat incurving toward the apex, and making an angle of radius and circumference where they meet the margin of the carapace. Posterior cleft a little less than $\frac{1}{2}$ the length of the carapace, margins curving slightly outward to meet the straight and parallel margins of the carapace at an angle of 46°. Dimensions: length, 50$^{mm}$, width of each *ala* across area of union, 18$^{mm}$. The surface is marked as in all of these species by low concentric ridges, somewhat crowded near the center, rather coarser in this species than in the others.

In the illustration (fig. 1) the form is given unintentionally somewhat larger than actual size, and one-half of the carapace is restored in its proper position.

In the light-greenish sandstones of the Lower Chemung, taken from a gully in the town of Canadice, Ontario Co., N. Y., six miles S.E. of the village of Hemlock.

### Dipterocaris Procne.

Area of union of the *alæ* midway between the anterior and posterior extremities, and reaching less than one-third the length of the test. Anterior and posterior clefts of the same length, the margins of the anterior having a somewhat greater inward curve as they pass to the margin of the carapace than those of the posterior.

The anterior angles made by the margins of the cleft, and the periphery are large—120°—but rounded. Posterior angles sharp—45°. Sides straight, anterior curvature abrupt. Dimensions: length, 23$^{mm}$; width of each *ala*, 9$^{mm}$.

Fig. 2 shows a carapace which has been flattened between the layers of sandstone, from the same locality as the preceding.

Fig. 3 shows both *alæ* not flattened, but probably at nearly their normal angle. From the sandstones of the Middle Chemung at Haskinsville, Steuben Co., N. Y.

This species differs from *D. pennæ-Dædali* in these particulars:

*a.* The anterior marginal curvature is more abrupt and shorter.

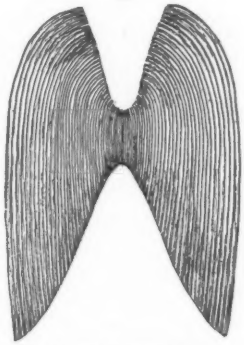
*b.* The area of union is larger and medially situated.

*c.* The cephalic and abdominal clefts are of the same length.

*d.* The individuals are, as far as observed, much smaller.

These details of difference are all well shown in the figures.

1.



*Dipterocaris pennæ-Dædali.*

2.

*Dipterocaris Procne.*

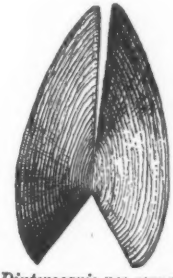
3.

*Dipterocaris Procne.*

4.

*Dipterocaris pes-cervæ.*

5.



*Dipterocaris pes-cervæ.*
(Enlarged 4 diameters.)

DIPTEROCARIS PES-CERVÆ.

Outline of carapace elongate lanceolate, area of union of *alæ* anterior, $\frac{1}{8}$th the length of the test. Cephalic cleft short, margins divaricating at an angle of 68° in the typical specimen and making angles of 78° with the periphery of the test. Posterior cleft long and narrow, the margins making an angle of 6° with each other, and angles of about 23° with the periphery. Dimensions: length 11$^{mm}$, width of each *ala* 3$\frac{1}{2}^{mm}$. From the sandy shales of the Lower Chemung in the cutting of the Delaware, Lackawanna & Western Railroad, at Dansville, Livingston Co., N. Y.

Fig. 4 represents the specimen natural size from which this species is described. Fig. 5, the same, enlarged 4 diameters.

The genera *Spathiocaris* and *Lisgocaris*, which have been described by myself in this Journal as noticed above, show, neither of them, any evidence of a dorsal suture in the carapace. At the time of my description of the genus *Spathiocaris*, the existence of this suture seemed a matter of considerable doubt, as many of the examples in my possession were folded laterally along a median line. More abundant material, however, places beyond a doubt the absence of any hingement, and the fact that the carapace is in one piece. The genus *Lisgocaris* was then proposed to cover a species differing from *Spathiocaris* as then apprehended, in the undoubted absence of this suture, and though rather an aberrant form from the type of the genus *Spathiocaris*, I think it wise, in the light of the additional material obtained, to abolish the name erected for it, and to include it under the genus *Spathiocaris*, the species there described to be *Sp. Lutheri*. With my present conception of these genera, I should not expect to find (though diligent and careful search has been made) any traces of a "rostrum" or free valve to cover the single cleft in *Spathiocaris*, as it does in the genera *Discinocaris* Woodward and *Peltocaris* Salter, which are allied to *Spathiocaris* in some of the grosser features, or to cover the cephalic cleft in *Dipterocaris*. In *Spathiocaris* the cleft seems to be posterior and for the protrusion of the abdomen. In *Dipterocaris* I am inclined to believe, for lack of any evidence to the contrary, that both clefts were uncovered and allowed the protrusion of the cephalic appendages as well as the abdominal somites.

The statement of the absence of the hingement, or the dorsal suture, in Dipterocaris, depends on these observations:

1. There is no mark upon the carapace evincing such a suture.

2. One example of *D. Procne*, having the entire carapace in its normal position, has been subjected to pressure from above by accumulating sediment, in just such a manner as would be most likely to separate the carapace along a dorsal suture if any existed, but instead of such separation the carapace has yielded in concentric wrinkles parallel to its margin.

3. Another example of the same species, flattened in a thin laminated sandstone, has been broken across the area between the apices of the anterior and posterior clefts, and in such a way as to have been left *with a ragged edge*.

Mr. R. P. Whitfield, in this Journal for Jan., 1880 (vol. xix, No. 109, p. 33, "Notice of New Forms of Fossil Crustaceans from the Upper Devonian Rocks of Ohio,") has presented a synopsis of the *Ceratiocaridæ* based upon features of the "cara-

pace alone, independent of the changes which take place in the abdominal segments and in the caudal spines and appendages." Seven sub-divisions of the family are made, the seventh of which includes the forms already mentioned as allied to *Spathiocaris* and *Dipterocaris*, namely, *Peltocaris* Salter, *Discinocaris* Woodward, and also *Aptychopsis* Barrande and *Pterocaris* Barrande, with this characterization. "Carapace composed of three pieces, or apparently of three, two of which are semicircular, with the anterior end of each obliquely truncate, forming, when the two are united, an anterior triangular notch into which the third or rostral plate is inserted; surface concentrically marked by growth lines; no nodes or ridges." None of the sections in this classification cover in as many particulars as this, the genera here and heretofore described by myself, and the description is quoted in full to emphasize the fact that, though the absence of the rostral piece can be regarded as only negative evidence, the unity of the carapace will preclude their admission to same footing as *Peltocaris*, *Aptychopsis* and *Pterocaris*. The genus *Discinocaris* stands apart from these three in the fact of its lack of a dorsal suture, as described (Quart. Jour. Geol. Soc. Lond., vol. xxii), and, with *Spathiocaris* and *Dipterocaris*, may stand as exemplifying a new type of carapace structure provided future investigation leads to the discovery of a rostral piece for the last two genera; otherwise they must remain apart from *Discinocaris* as well as from the other genera mentioned. All of the genera making the somewhat heterogeneous family of the *Ceratiocaridæ*, with the addition of their modern representative *Nebalia*, have been elevated by Packard to the value of an order with the name Phyllocarida.

I take this opportunity of acknowledging my obligation to Mr. C. E. Beecher, of the Geological Survey of New York, for kindness shown me in the confidence of his unpublished observations on new forms of the *Ceratiocaridæ* from the Pennsylvania Devonian, and in the loan of his beautiful drawings for comparative study.

Smith College, Northampton, Mass.

ART. XIII.—*On a Method of Photographing the Solar Corona without an Eclipse;** by WILLIAM HUGGINS, D.C.L., LL.D., F.R.S.

PROBLEMS of the highest interest in the physics of our sun are connected, doubtless, with the varying forms which the coronal light is known to assume, but these would seem to admit of solution only on the condition of its being possible to study the corona continuously, and so to be able to confront its changes with the other variable phenomena which the sun presents. "Unless some means be found," says Professor C. A. Young, "for bringing out the structures round the sun which are hidden by the glare of our atmosphere, the progress of our knowledge must be very slow, for the corona is visible only about eight days in a century, in the aggregate, and then only over narrow stripes on the earth's surface, and but from one to five minutes at a time by any one observer."†

The spectroscopic method of viewing the solar prominences fails, because a large part of the coronal light gives a continuous spectrum. The successful photograph of the spectrum of the corona taken in Egypt, with an instrument provided with a slit, under the superintendence of Professor Schuster during the solar eclipse of May 17, 1882, shows that the coronal light as a whole, that is the part which gives a continuous spectrum, as well as the other part of the light which may possibly be resolved into bright lines, is very strong in the region of the spectrum extending from about G to H. It appeared to me, therefore, very probable that by making exclusive use of this portion of the spectrum it might be possible under certain conditions, about to be described, to photograph the corona without an eclipse.

In the years 1866–68 I tried screens of colored glasses and other absorptive media, by which I was able to isolate certain portions of the spectrum, with the hope of seeing directly, without the use of the prism, the solar prominences.‡ I was unsuccessful, for the reason that I was not able by any glasses or other media to isolate so very restricted a portion of the spectrum as is represented by a bright line. This cause of unsuitableness of this method for the prominences which give bright lines only, recommends it as very promising for the corona. If by screens of colored glass or other absorptive media the region of the spectrum between G and H could be isolated, then the coronal light which is here very strong would have to contend only with a similar range of refrangibility of the light scat-

* Nature, Dec. 29. Communicated in proof for this Journal, by the author.

† "The Sun," p. 239.

‡ "Monthly Notices," vol. xxviii, p. 88, and vol. xxix, p. 4.

tered from the terrestrial atmosphere. It appeared to me by no means improbable that under these conditions the corona would be able so far to hold its own against the atmospheric glare, that the parts of the sky immediately about the sun where the corona was present would be in some degree brighter than the adjoining parts where the atmospheric light alone was present. It was obvious, however, that in our climate and low down on the earth's surface, even with the aid of suitable screens, the addition of the coronal light behind would be able to increase, but in a very small degree, the illumination of the sky at those places where it was present. There was also a serious drawback from the circumstance that although this region of the spectrum falls just within the range of vision, the sensitiveness of the eye for very small differences of illumination in this region near its limit of power is much less than in more favorable parts of the spectrum, at least such is the case with my own eyes. There was also another consideration of importance, the corona is an object of very complex form, and full of details depending on small differences of illumination, so that even if it could be glimpsed by the eye, it could scarcely be expected that observations of a sufficiently precise character could be made to permit of the detection of the more ordinary changes which are doubtlessly taking place in it.

These considerations induced me not to attempt eye-observations, but from the first to use photography, which possesses extreme sensitiveness in the discrimination of minute differences of illumination, and also the enormous advantage of furnishing a permanent record from *an instantaneous exposure* of the most complex forms. I have satisfied myself by some laboratory experiments that under suitable conditions of exposure and development a photographic plate can be made to record minute differences of illumination existing in different parts of a bright object, such as a sheet of drawing paper, which are so subtle as to be at the very limit of the power of recognition of a trained eye, and even, as it appeared to me, of those which surpass that limit.

My first attempts at photographing the corona were made with photographic lenses, but uncertainty as to the state of correction of their chromatic aberration for this part of the spectrum, as well as some other probable sources of error which I wished to avoid, led me to make use of a reflecting telescope of the Newtonian form. The telescope is by Short, with speculum of 6 inches diameter, and about 3½ feet focal length. A small photographic camera was fastened on the side of the telescope tube, and the image of the sun after reflection by the small plane speculum was brought to focus on the ground glass. The absorptive media were placed immediately in front of the sen-

sitive film, as in that position they would produce the least optical disturbance. Before the end of the telescope was fixed a shutter of adjustable rapidity which reduced the aperture to 2 inches. This was connected with the telescope tube by a short tube of black velvet for the purpose of preventing vibrations from the moving shutter reaching the telescope. On account of the shortness of the exposure it was not necessary to give motion to the telescope.

It was now necessary to find an absorptive medium which would limit the light received by the plate to the portion of the spectrum from about G to H. There is a violet (pot) glass made, which practically does this. I had a number of pieces of this glass ground and polished on the surfaces. Three or four of these could be used together, castor-oil being placed between the pieces to diminish the reflection of light at the surfaces. Some inconvenience was found from small imperfections within the glass, and it would be desirable in any future experiments to have a larger supply of this glass, from which more perfect pieces might be selected.

In my later experiments I used a strong and newly made solution of potassic permanganate, in a glass cell with carefully polished sides. This may be considered as restricting the light to the desired range of wave-length, since light transmitted by this substance in the less refrangible parts of the spectrum does not affect the photographic plates.

Different times of exposure were given, from so short an exposure that the sun itself was rightly exposed, to much more prolonged exposures, in which not only the sun itself was photographically reversed, but also the part of the plates extending for a little distance from the sun's limb.

Gelatine plates were used, which were backed with a solution of asphaltum in benzole.

After some trials I satisfied myself that an appearance peculiarly coronal in its outline and character was to be seen in all the plates. I was, however, very desirous of trying some modifications of the method described with the hope of obtaining a photographic image of the corona of greater distinctness, in consequence of being in more marked contrast with the atmospheric illumination.

Our climate is very unpropitious for such observations, as very few intervals, even of short duration, occur in which the atmospheric glare immediately about the sun is not very great. Under these circumstances I think it is advisable to describe the results I have obtained without further delay.

The investigation was commenced at the end of May, 1882, and the photographs were obtained between June and September 28th.

The plates which were successful are twenty in number. In all these the coronal form appears to be present. This appearance does not consist simply of increased photographic action immediately about the sun, but of distinct coronal forms and rays admitting in the best plates of measurement and drawing from them. This agreement in plates taken on different days with different absorptive media interposed, and with the sun in different parts of the field, together with other necessary precautions observed, makes it evident that we have not to do with any instrumental effect.

The plates taken with very short exposures show the inner corona only, but its outline can be distinctly traced when the plates are examined under suitable illumination. When the exposure was increased, the inner corona is lost in the outer corona, which shows distinctly curved rays and rifts peculiar to it.

In the plates which were exposed for a longer time, not only the sun but the corona also is photographically reversed, and in these plates, having the appearance of a positive, the white reversed portion of the corona is more readily distinguished and followed in its irregularly sinuous outline than is the case in those plates where the sun only is reversed, and the corona appears, as in a negative, dark.

Professor Stokes was kind enough to allow me to send the originals to Cambridge for his examination, and I have his permission to give the following words from a letter I received from him: "The appearance is certainly very corona-like, and I am disposed to think it probable that it is really due to the corona." Professor Stokes' opinion was formed from the appearance on the plates alone, without any knowledge of their orientation, and without the means of comparing them with the eclipse plates taken on May 17.

I have since been allowed, through the kindness of Captain Abney, to compare my plates with those taken of the corona in Egypt during the eclipse of May last. Though the corona is undergoing doubtless continual changes, there is reason to believe that the main features would not have suffered much alteration between May 17th and September 28th, when the last of my plates was taken. This comparison seems to leave no doubt that the object photographed on my plate is the corona. The more prominent features of the outer corona correspond in form and general orientation, and the inner corona, which is more uniform in height and definite in outline, is also very similar in my plates to its appearance in those taken during the eclipse.

Measures of the average height of the outer and of the inner corona in relation to the diameter of the sun's image are

the same in the eclipse plates as they are in my plates taken here.

There remains little doubt that by the method described in this paper, under better conditions of climate, and especially at considerable elevations, the corona may be successfully photographed from day to day with a definiteness which would allow of the study of the changes which are doubtlessly always going on in it. By an adjustment of the times of exposure, the inner or the outer corona could be obtained as might be desired. It may be that by a somewhat greater restriction of the range of refrangibility of the light which is allowed to reach the plate, a still better result may be obtained.

Plates might be prepared sensitive to a limited range of light, but the rapid falling off of the coronal light about H would make it undesirable to endeavor to do without an absorptive screen. Lenses properly corrected might be employed, but my experience shows that excessive caution would have to be taken in respect of absolute cleanness of the surfaces and of some other points. There might be some advantage in intercepting the direct light of the sun itself by placing an opaque disk of the sun's image upon the front surface of the absorptive screen. I regret that the very few occasions on which it has been possible to observe the sun has put it out of my power to make further experiments in these and some other obvious directions.

---

[I have Captain Abney's permission to add the following letter this day received from him. "A careful examination of your series of sun-photographs, taken with absorbing media, convinces me that your claim to having secured photographs of the corona with an uneclipsed sun, is fully established. A comparison of your photographs with those obtained during the eclipse which took place in May last, shows not only that the general features are the same, but also that details, such as rifts and streamers, have the same position and form. If in your case the coronal appearances be due to instrumental causes, I take it that the eclipse photographs are equally untrustworthy, and that my lens and your reflector have the same optical defects. I think that evidence by means of photography of the existence of a corona at all is as clearly shown in the one case as in the other." —*Dec.* 15, 1882.]

ART. XIV.—*An Account of Observations of the Transit of Venus, 1882, made at the Lick Observatory, Mount Hamilton, California;* by DAVID P. TODD, M.A., Professor in Amherst College. (Communicated by the Trustees of the James Lick Trust.)

IN a letter from Captain R. S. Floyd, President of the Trustees, received at Amherst the 7th November last. I was invited to direct the observations of the transit of Venus at the Lick Observatory. I went to Washington as soon as possible, accompanied by Mr. J. L. Lovell, of Amherst, whom I had selected to have charge of the photographic operations in connection with observing the transit. While there, Mr. Lovell received from Professor Harkness and Mr. Rogers such instructions in regard to the special photographic manipulations as our limited time would permit. We left Washington on the morning of the 14th November, arriving in San Francisco at noon the sixth day after. Here we were met by Mr. Thomas E. Fraser, the Superintendent of Construction of the Observatory. A few hours sufficed for the purchase of such portions of the astronomical, photographic and mechanical outfit as had not already been provided; and we were enabled to arrive on the summit of the mountain early in the evening of the 21st. Two weeks then remained before the day of the transit, for completing the unfinished portions of the photoheliograph, mounting and adjusting the same, and making all the photographic and other preparations. Very little time ran to waste, and through the consecutive and uniformly harmonious exertion of every one on the mountain—no one failing in the least of that enthusiastic appreciation which alone could have insured the early attainment of our end—all the apparatus was readily brought into its final condition of certain, convenient and effective working.

*Meteorological.*—It was our good fortune that the conditions of weather during these two weeks were, in general, very favorable for this preparatory work. No snow fell, and on only two days had we any rains—these very slight. Violent winds interfered with our operations on three or four days. The temperature was rarely below 50°, and most of the time above 60°.

At midnight, the 30th November, the sky cleared, after three and a half days of continuously cloudy weather. From that time until the afternoon of December 7th, we saw no cloud, day nor night, which could interfere in the least with any observation we had to make. Thin cirrus was floating above the summit on the morning of the 2d, but it had van-

ished completely within two hours; and on three or four occasions clouds were observed very near the horizon, but they never rose. The wind blew in fitful gusts night and day the 3d and 4th, and the morning of the 5th. But very soon after 12 o'clock, that day, the winds entirely subsided, and for the next fifty or sixty hours the utmost tranquility prevailed, the temperature never falling below 60°, and rising to very near 70° in the shade at noon on the day of the transit.

*Optical.*—The sun rose about 7 o'clock, December 6th, with Venus a good way on its disk. The planet was observed by Captain Floyd at intervals throughout the time of transit, with the twelve-inch equatoreal of the Observatory; and with this instrument he made several drawings, and observed the two contacts at egress. The photographic operations were suspended just before the two contacts; and I observed these with the four-inch transit instrument, mounted on its reversing carriage.

*Photographic.*—The horizontal photoheliograph, with which the pictures of the transit of Venus were taken was constructed by Alvan Clark & Sons, and is, in all essential parts, entirely similar to those made by the same makers for the American Transit-of-Venus Commission. The general theory of this instrument was first published by Professor Harkness in volume xliii of the Memoirs of the Royal Astronomical Society; and subsequently by Professor Newcomb in the "American Observations of the Transit of Venus," 1874, Part I, where a detailed description of the instrument, with plates, is also given.

The Lick photoheliograph, like all the others, has an objective five inches in diameter. Its focal length is almost exactly 40 feet—that is, about $\frac{1}{30}$th part greater than the mean focal length of the eight instruments of the Commission. The diameter of the mirror is a little greater than seven inches; and, unlike the instruments of the Commission, the mechanism supporting the mirror is compactly connected with the clockwork which drives it—all being mounted on a single pier. The objective was mounted on an adjacent pier, and the plate-holder on a third pier coming up in the interior of the photographic house. These piers were all set in the meridian of the transit instrument, and were laid up of brick, their foundation being in the rock of the mountain summit, and their size sufficiently large to insure their absolute stability in every part. The first pictures with the Lick photoheliograph were made with dry plates by Captain Floyd, November 19th, two days before I arrived on the mountain. These confidently assured me that the instrument, although not then in adjustment, and in some parts lacking, was capable of work of the best sort. A suitable exposing-slide had not been provided by the makers; this, however, arrived within two or three days, and

was immediately put in place. The jaw-micrometer and the measuring-rod were received on the mountain in due time before the transit. Three piers were built at once between the transit house and the heliostat, for supporting the tripod of the engineer's level to be used in finding the level-error of the photographic telescope. The tube of this telescope, about thirty-eight feet long and without diaphragms, was cut near the middle, and the half near the objective removed. A tube was then made, about nineteen feet long, of thin plates of iron, diaphragms of sheet lead being inserted as the several sections were riveted together. This tube was a half inch less in diameter than the original tube, and was slipped inside of the remaining half of it—thus giving an air-space between the two tubes, in addition to that between the wooden awning and the exterior tube.

A hood fifteen inches square was made of card-board to cover the plate-holder and the upper part of the pier on which it rested. This was blackened inside, and hinged to the wall of the photographic house, so that it could be pushed up and out of the way when the plates were being put into the holder or taken out. The hood was always pulled down before making the exposure, and thus the momentary flash of light through the photographic house on drawing the exposing-slide, was entirely obviated.

Great care was taken to prevent the mishap of fogged plates from any light falling upon the sensitive film other than that of the sun from the first face of the heliostat mirror. After the adjustments of the heliostat and objective were complete, the following test was applied:—a section of thin iron pipe two feet long and five inches in diameter was fitted with a stopper at one end, and painted jet black outside and in. The sun's image was adjusted centrally on the reticle-plate, the clock-work maintaining it there. The pipe was next set up at various points between the objective and plate-holder, the stopped end being toward the photographic house. Then the pipe being so adjusted that its axis was coincident with the axis of the photographic telescope, the eye of an observer located south of the plate-holder, and looking north through the tube, would readily detect the presence of any object which appeared sufficiently luminous to affect the sensitive plate.

The first photographs of the sun by the wet process—which was adopted in making all our pictures of the transit—were taken November 27th; and we soon after began the accumulation of ample data for the precise determination of the photographic focus of the objective. Sets of photographs, ranging from five to twelve, were taken on six different days, the posi-

tion of the plate-holder being duly changed and recorded between the several photographs of each set. Before the plate-holder was secured in its final position, each photographer had critically inspected all these plates; and without conferring with any one else had made a memorandum of, the numbers of those plates in each set which he regarded as indicating the best focus. In addition to this, nearly all the trial-plates were examined independently by Captain Floyd and Mr. Fraser, and all of them on two separate occasions by myself. Nearly all the different determinations were, when collated, in surprising agreement; and the adopted setting of the plate-holder could not have been in error by so much as the $\frac{1}{4000}$th part of the focal length of the objective. In point of fact, the position of the focal plane was definitely indicated to the $\frac{1}{8000}$th part. The superior definition of the photographs of the transit was an entire compensation for all this trouble.

The first photograph of the transit of Venus was taken at $19^h\ 11^m$, local mean time. The exposure was $1\frac{1}{2}^s$ long, and the slit $3^{in}\cdot0$ wide. Only a very faint image came out on the plate. The fourth exposure, somewhat shorter, and with the slit the same width, at $19^h\ 17^m$, gave a picture sufficiently intense for measurement; but the vertical diameter of the sun was something like $\frac{1}{4}^{in}$ shorter than the horizontal one, and the limb was not well defined. Plate No. 13, at $19^h\ 50^m$, slit $1^{in}\cdot0$ in width, and exposure $0^s\cdot4$ long, is the first photograph of real value, though the five immediately preceding it may be worth measuring. The width of the slit was gradually reduced as the altitude of the sun became greater, being successively $0^{in}\cdot75$, $0^{in}\cdot5$ and $\frac{3}{8}^{in}$, until at $21^h\ 20^m$, it was set at a width of $0^{in}\cdot25$, and was so kept until the end. The exposures were quite uniformly $0^s\cdot25$ in length.

Three records of the times of exposures were kept—one automatically on the chronograph, the circuit being broken at the precise instant when the middle of the slit passed the central vertical line of the reticle-plate; a second record, by myself, taken from the mean time chronometer in the dark room, and set down at once in the photographic record; and a third record, kept in the transit house by Mrs. Floyd, assisted by Mrs. Fraser, the approximate time of the exposure-click of the chronograph-armature being taken from the face of the sidereal chronometer. As neither the observation of the mean-time chronometer time of the exposure, nor the automatically recorded sidereal-chronometer time, could properly be regarded as complete without the corresponding number of the photograph, this latter was, in every instance, made equally a matter of observation with the time itself; and no plate was ever exposed until I had myself seen and recorded the number it

bore. The chronograph was attended by Professor Welcker, late of the University of California, who made also the observations with the thermometer and barometer.

Thirteen reversals of the plumb-line were made during the period of the exposures. The exposing-slide was moved to the east and to the west, alternately with each exposure, this order never being varied for any reason whatever. I invariably moved the slide, and made all the necessary entries pertaining to each picture in the photographic record myself. The temperature of the photographic house, in which there was no fire, was frequently read from a standard thermometer, the range being from 65°·7 at $19^h\ 51^m$, to 75°·4 at $23^h\ 38^m$. This latter was the time of the last exposure preceding interior contact at egress. After I had observed this contact optically, ten additional exposures were made.

Of the *Photographic Record* proper there are three copies; the original was deposited in the vault of the Observatory, the duplicate is now in my possession at Amherst, and the triplicate was left in the safe of the Lick Trust Office, San Francisco.

The total number of plates exposed was 147. Subtracting from this number all those exposed at the beginning of the day, the ten made between the two contacts at egress, a few worthless ones, and all others of doubtful value, the total number of plates which are available for micrometric measurement cannot fall far short of 125, and may somewhat exceed that number.

Before the plates were finally packed in the boxes I made a comparative estimate, based on a somewhat rapid examination, of the value of these photographs of the transit. Each plate was taken up in order, and a mark assigned to it, on the scale A, A−, B+, B, B−. The mark A means that the plate was judged to be of the very first quality, and capable of the most accurate measurement. Those marked A− are a shade inferior. Second grade plates are designated by B, those a shade better, but not so good as A−, being marked B+; while those not quite up to the grade B are marked B−. A few were judged to be worth only a still lower mark, C. The result was as follows:

| | | | | |
|---|---|---|---|---|
| A | 71 | B | 9 | Total, 123 |
| A− | 23 | B− | 3 | |
| B+ | 13 | C | 4 | |

Mr. Lovell was ably assisted in the photographic work by Mr. Milton Loryea, of San José, whose services were very kindly rendered to the Observatory without compensation, and by Mr. A. P. Flaglor and Mr. O. V. Lange, who were engaged from San Francisco.

*Storing of the Photographic Plates, etc.*—After the quality of the photographs had been noted in detail, they were carefully packed in boxes of the ordinary pattern, and these latter stored in the upper part of the vault forming the interior of the brick pier, which supports the twelve-inch equatoreal. Tests for absence of moisture were applied to this vault, and as it has the means of pretty thorough ventilation, it is difficult to see how the photographs could be in a more secure place.

Four of the photographs were brought by Captain Floyd to San Francisco and placed in the vaults of the Safe Deposit Company of that city. Within a few days I have sent him the numbers of twenty-four additional plates which he intends bringing down at an early day for safe keeping in the same place. These twenty-eight plates are so selected that in the event of destruction of all those remaining on the mountain, they will of themselves give a very satisfactory record of the transit as seen from Mount Hamilton.

Before I left the summit for San Francisco, there were also stored in the Observatory vault the following parts of the photoheliograph, the constants of which have yet to be investigated:

I. The measuring-rod (in five sections).
II. The jaw-micrometer.
III. The Chesterman steel tape (50 feet).
IV. The heliostat mirror.
V. The photographic objective.
VI. The reticle-plate.

All these were so marked that no doubt can ever arise in regard to the station at which they were used. In addition to the five-section rod used in determining the focal length of the photographic objective, there is on the mountain another rod, of similar pipe-material, which has been carefully compared with the principal rod. This additional rod was left in position over the tube of the photographic telescope. It is made up of three lengths of pipe, put together in the ordinary plumber-fashion, the joints being so marked that the lengths may be brought up always to the same relative position to each other. In the possible event of loss or destruction of the five-section rod, this additional rod will at any time give the focal length of the photographic telescope with nearly equal accuracy.

In conclusion, it is proper that I should remark the full generosity with which the entire outfit for our work on the mountain was provided by the Trustees, and which, while it was in no sense lavish, contributed very largely to the success so gratifying to us all.

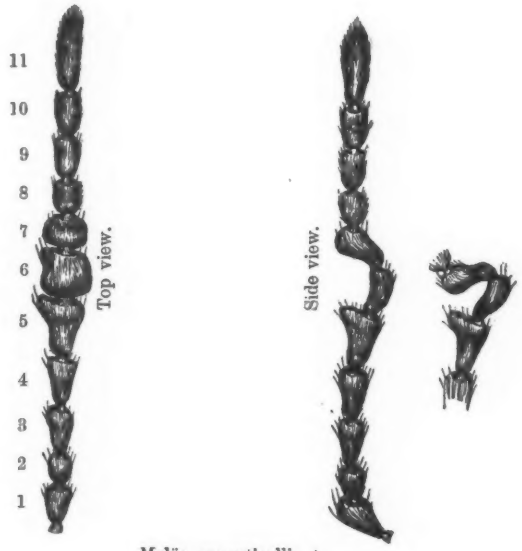
Lawrence Observatory, Amherst, Mass.,
January 16, 1883.

ART. XV.—*On the Antenna of Melöe;* by FRANKLIN C. HILL.

THE antenna of Melöe, male, is so peculiar in form that it has been described by every coleopterist who has seen it, and apparently by some who have not.

This peculiarity consists in a geniculation or hinge involving the fifth, sixth and seventh joints.

The descriptions of this hinge given by European writers vary greatly, even to the extent of locating it in different joints and different numbers of joints, in the same species, *M. proscarabæus* being the one most commonly described, and their drawings are equally varied, very few giving any true idea of the structure.




Melöe angusticollis ♂.
Right antenna × 8.

The American drawings of *M. angusticollis* which I have met with only differ from each other in badness, and the descriptions are worse than the cuts. In Harris's "Injurious Insects" the hinge is located rightly though badly drawn, and in Packard's "Guide" it is worse drawn and wrongly located, while Le Baron in his "Fourth Report," in making a copy of Packard's cut, preserves the errors in the antennæ, and adds a variety of others in the tarsi and abdomen. Both European

and American authors apply a number of terms to the antennæ, as "twisted and knotted," "remarkably swollen and knotted," "writhed or distorted," etc., which do not at all describe it, and no one with whom I have met takes any notice of the remarkable flexure between the sixth and seventh joints which leads me to speak of the geniculation as a "hinge;" and of course they do not hint at a use for the hinge, while one of our best entomologists assured me recently that no use has been found for it.

My drawing shows that it is made up of the fifth, sixth and seventh joints. The fifth is club-shaped, the distal end expanding suddenly inward and downward. The sixth is flattened and nearly square, when seen from above, the outer distal corner being rounded off. Viewed sideways it is slightly arched. The seventh joint is also flattened and when seen sideways has a sigmoid curvature. There is considerable mobility between all the joints involved, but it is greatest between the sixth and seventh, the latter of which folds down until its swollen top almost, if not quite, touches the projecting top of the fifth, making a sort of clasp.

This power of grasping something implies something to be grasped; and after some years of watching, having captured a pair of the beetles last October, I had the pleasure of seeing what that something is, and now can hardly believe that others have not also seen it, though I am unable to find their record. The use is evidently sexual.

In *M. angusticollis*, the male, after placing his mouth against the occiput of the female, kept up a brisk motion there with his trophi, at the same time reaching forward with his antennæ and clasping hers in his hinges, at about the sixth joints.

There seems to be no peculiarity in the antennæ of the female, unless it be that the sixth joints are a little larger than the others, and that there is a slight flexure between the sixth and seventh.

Often, as he closed his hinges, the female drew her antennæ out of them, only to have them seized again at once. When she allowed him to retain them for a moment, he would move backward, drawing her antennæ with his like a bridle. My observations have not succeeded in obtaining further facts; but they are sufficient to convince me that the hinge is "directly connected with reproductive functions," although assured to the contrary on very high authority.

Princeton, New Jersey, December 5, 1882.

ART. XVI.—*Communications from the U. S. Geological Survey: Rocky Mountain Division.*

III. *On Hypersthene-andesite;** by WHITMAN CROSS.

IN the course of the investigation of some apparently normal augite-andesites, of the most typical variety, occurring at the Buffalo Peaks in South Park, Colorado, the writer found that a large part of the pyroxenic constituent possessed the crystalline form and chemical constitution of *hypersthene* rather than of augite. The comparative study of similar andesites from this country and from well-known European localities has forced him to the conclusion that in very many, if not in all of them, augite is decidedly subordinate to a rhombic pyroxene, which is presumably hypersthene. As this conclusion, if proven to be correct, affects materially the current classification of andesitic rocks, the grounds upon which it is based will be concisely stated.

*Hypersthene-andesite from Buffalo Peaks, Colorado.*

The rock in question occurs in mass, associated with a number of other andesites, prominent among which is a normal hornblende-andesite, and too in fragments imbedded in an important series of volcanic tufas, also of andesitic character. For further information concerning these rocks, the reader must be referred to the forthcoming "Report upon the Geology and Mining Industry of Leadville, Colorado," by S. F. Emmons.

The rock with which we are now occupied is very compact, almost black in color, showing macroscopically a large number of small glassy feldspars, and a few dark, green grains. The ground-mass in which these crystals lie has a dull vitreous luster. When examined under the microscope in ordinary light the rock seems to be an augite-andesite of very typical composition and structure. Clear plagioclase crystals and pyroxene in small crystals and irregular grains, with magnetite and apatite, are the only mineral constituents to be recognized. These larger individuals lie in a ground-mass composed of delicate staves of plagioclase, light green microlites of pyroxene and minute octahedra of magnetite, with a glass base between them, which is usually clear, though sometimes devitrified by light brownish globulites.

* This article is an abstract of a paper to be published as a Bulletin by the U. S. Geological Survey. Its publication has already been delayed for several months, and as a further delay in the Public Printing Office is anticipated, it is deemed best to present the chief results in this form.

The description so far would answer for almost any representative of that sub-group of the andesites usually spoken of as "original" or "normal augite-andesite," or as "Augit-andesit im engeren Sinne," and which is found with unvarying characteristics in Hungary, Transylvania, the Andes of South America, in many islands of the South Pacific, and in the Western United States.

When, however, the pyroxene crystals and grains of the Buffalo Peaks rock are examined in polarized light, it is clear that a large portion of them do not belong to the monoclinic augite. If, in the first place, all those individuals of which the vertical axis seems to lie in, or nearly in, the plane of the thin section, be examined, it is seen that much more than half of them are very distinctly dichroic, and that all of these extinguish light parallel to the vertical axis. The others are not visibly dichroic, and extinction takes place at a very decided angle, usually approaching 40° from the vertical axis.

If, on the other hand, those crystals which are apparently cut at right angles to the principal axis (judging from cleavage and outline) are tested, more than half of them are found to extinguish light when the diagonals of the prism, as indicated by the best developed cleavage planes, coincide with the principal sections of the crossed Nicols. In the remainder there is a very pronounced variation from this action, and one which is not reconcilable with a normal monoclinic or rhombic pyroxene. The limited space of this article prevents an extended discussion of this latter point, which will, however, be fully treated in the bulletin mentioned in the introductory note. It will here suffice to say that from the observations made upon a large number of pyroxene rocks, it seems probable that a triclinic species exists with a crystalline form closely imitating that of the monoclinic system and of a composition identical with common augite.

To return to those dichroic longitudinal sections which extinguish light parallel to the vertical axis: they are pale green in color when that axis is perpendicular to the principal section of one Nicol and greenish-yellow to yellowish-brown when it lies in the Nicol section. The changes cannot be exactly described where the position of the lateral axes is undeterminable. In cross sections neither mineral exhibits marked dichroism. The pleochroism observed in this case does not seem to differ from that often described for the "augite" of the andesites. It is also true that a section of augite parallel to the orthopinacoid cannot be distinguished optically from rhombic pyroxene, as both give extinction parallel to the prismatic axis. It is, however, unreasonable to suppose, even for a single thin section of a massive rock, that any large proportion of the augite crystals of which the prismatic development can be seen are by chance

so situated that the ortho-axis falls in the plane of the section. In all of the sections prepared from the various specimens of Buffalo Peaks "augite-andesite," a majority and usually a large majority of the prismatic sections of pyroxene gave extinction parallel to the vertical axis.

Believing that the optical behavior indicated the presence of rhombic pyroxene in this andesite, and bearing in mind the results obtained by Fouqué in his researches on the Santorin lavas, an attempt was made to confirm the microscopical determination by the isolation and analysis of the questionable mineral. The method of procedure adopted was the same which was used by Fouqué.* A specimen of rock was chosen in which according to the microscopical diagnosis the rhombic pyroxene predominated but slightly over the other, which will be called augite for convenience, though much of it differs optically from that mineral, as has been described. After being suitably crushed, the rock-powder was treated with strong hydrofluoric acid until all but the iron-bearing minerals, pyroxene and magnetite, were dissolved. The latter mineral and such crystals of pyroxene as contained inclusions of it were then extracted with a magnet. The microscopical examination of the residue showed more clearly than ever that two distinct minerals were present, the one markedly pleochroic and seemingly rhombic, the other having the appearance of ordinary augite. This mixture was then further treated with HFl until about one-half had been dissolved. The remainder was found to consist almost entirely of the pleochroic mineral with but a very small amount of the augite. This residue was then subjected to a quantitative analysis.

In this manner the apparently rhombic mineral was isolated from two different rocks from Buffalo Peaks, and the operation was repeated for one of them. Both the isolation and the analysis of the mineral were performed by Mr. W. F. Hillebrand, chemist to the Rocky Mountain Division of the Survey.

The results obtained are presented in the following table. Analysis I is of the whole rock; II and III of portions of the mineral isolated at different times from the rock analyzed; IV of the same from another rock; V† the analysis given by Fouqué for the hypersthene of a Santorin lava; VI‡ hypersthene from Labrador.

* F. Fouqué. "Santorin, et ses éruptions," Paris, 1879, p. 190.
† Santorin et ses éruptions, p. 195.
‡ J. D. Dana. System of Mineralogy, p. 210.

| | I. | II. | III. | IV. | V. | VI. |
|---|---|---|---|---|---|---|
| Sp. gr. | 2·742 | | | 3·307 | 3·477 | |
| $SiO_2$ | 56·190 | 51·703 | 51·157 | 50·043 | 50·12 | 51·36 |
| $Al_2O_3$ | 16·117 | 1·720 | 2·154 | 2·906 | 2·12 | 0·37 |
| $Fe_2O_3$ | 4919 | 0·304 | ------ | ----- | 1·60 | ----- |
| FeO | 4·433 | 17·995 | 18·360 | 17·812 | 23·59 | 21·27 |
| MnO | trace | 0·363 | 0·363 | 0·120 | ---- | 1·32 |
| CaO | 6·996 | 2·873 | 3·812 | 6·696 | 10·49 | 3·09 |
| MgO | 4·601 | 25·091 | 24·251 | 21·744 | 11·05 | 21·31 |
| $K_2O$ | 2·368 | ------ | ------ | ----- | ---- | ----- |
| $Na_2O$ | 2·961 | ------ | ------ | 0·274 | 0·67 | ----- |
| $H_2O$ | 1·028 | ------ | ------ | ----- | ---- | ----- |
| $P_2O_5$ | 0·266 | ------ | ------ | ----- | ---- | ----- |
| Cl | 0·022 | ------ | ------ | ----- | ---- | ----- |
| | 99·901 | 100·049 | 100·097 | 99·595 | 99·64 | 98·72 |

In analyses III and IV the total amount of iron is given protoxide, the small quantity of available material rendering satisfactory results impossible. An amount corresponding to that given in II is to be considered as sesquioxide. The MnO of III is taken from II, and is undoubtedly very nearly correct, the portions being derived from the same rock. The microscopic investigation of the material giving results II and III showed an almost total absence of any other substance than the hypersthene. Not more than one per cent of the material could possibly be considered as augite. The method of obtaining the material preserves the crystalline form for most individuals, so that on being mounted in balsam the great majority of the grains lie with the vertical axis in the plane of the slide and the extinction can be clearly seen. In the rock which furnished the material for IV the hypersthene is much better formed than the augite, and the powder of hypersthene finally obtained contains many crystals fully as well developed as those figured by Fouqué for one of the Santorin lavas.* In IV is included a small amount of feldspar attached to hypersthene grains, and which could not be dissolved without losing too much of the latter mineral.

The results obtained, in connection with the optical properties of the mineral, fully justify the application of the name *hypersthene* to the pyroxene, which, in all of the Buffalo Peaks rocks of the type under discussion, is by far the predominating bisilicate. The three analyses given are all very near the theoretical requirements for normal hypersthene, being in fact much nearer than that given by Fouqué, though the correctness of his determination has not been questioned.

* "Santorin et ses éruptions." Plate LX, fig. 2.

*Results of the comparative study of the so-called "Augite-andesites."*

The limited space of this article does not allow a full discussion of the grounds upon which the conclusion reached by the writer is based. They are, however, stated at length in the forthcoming Bulletin.

A careful study of thin-sections of all the "augite"-andesites of the normal type referred to above which are at the command of the writer, some 31 in number, and representing especially the rocks of Hungary and the Western United States, shows that a rhombic pyroxene is more abundant than augite in each and every one of them. This statement rests chiefly upon the numerical ratio found to exist between those prismatic sections of pyroxene, giving extinction parallel to the vertical axis, and those with oblique extinction. In every case examined the number of the former is greater than that of the latter. In some rocks no distinctly monoclinic pyroxene could be found. Such evidence cannot be ignored simply because there is a possible position for a monoclinic prism in which it cannot be distinguished from a rhombic by the test of extinction. The frequency with which such a position is liable to occur in massive rocks may be fairly ascertained by testing the extinction of hornblende in diorite, or of augite in diabase, in the manner above indicated.

It may be thought strange that the true character of the pyroxene, in so many well-known rocks, has so long escaped detection. A single instance will here be cited, however, which will serve to partially explain the fact. The single hypersthene-andesite mentioned by Rosenbusch, in his standard work, "Die mikroskopische Physiographie der massigen Gesteine," p. 480, has been annihilated by Dr. E. Hussak with the following casual remark: "Eine an neuem Materiale unternommene optische Untersuchung des augitischen Gemengtheiles ergab, dass derselbe nicht rhombisch, wie er bisher bezeichnet wurde, sondern monosymmetrisch ist, da in den klinodiagonalen Längsschnitten desselben der eine optische Hauptschnitt der Längsaxe nicht parallel geht, sondern schief zu derselben steht, und die Auslöschungsschiefe zu über 30° gemessen wurde. Das Gestein ist demnach ein echter Augit-andesit." (Neues Jahrbuch, etc., 1880, i, 290.) Hussak had previously examined the original material and pronounced the designation hypersthene-andesite as correct.* Upon finding some augite in another specimen from the same locality, he concludes that it is "echter Augit-andesit." This latter conclusion is often cited, and so far as is known to the writer has not

* Verhandl. d. k. k. geol. Reichsanstalt. 1878, p. 338.

been questioned. This case simply illustrates the fact that most observers have not considered the possibility of two pyroxenes occurring together in the andesites, and the results obtained by Fouqué, who isolated both augite and hypersthene from the Santorin lavas, have been passed over as interesting but unique.

In conclusion, the writer must not be misunderstood as claiming that all so-called "augite-andesites," of the type described in the beginning of this article, are hypersthene rocks. It is a fact, however, that all of that type which are accessible to him seem to be so, and that no hypersthene rock has been found in any other structural variety of the andesites.

Chemical investigations are now in progress upon several well-known rocks of Hungary which are cited by Zirkel and Rosenbusch as types of "Augit-andesit," and the results will be communicated at an early day.

Denver, Colorado, December, 1882.

---

ART. XVII.—*A New Method for determining the Collimation Constant of a Transit Circle;* by J. M. SCHAEBERLE.

THE collimation constant of a transit instrument is usually determined by one of the four following methods:

1. By observations of stars in reversed positions of the instrument.

2. By reversal on a collimator or very distant terrestrial object.

3. By combining observations made with the spirit level with nadir observations.

4. By Bessel's method, in which two horizontal collimators (placed on opposite sides of the instrument and having their optical axes parallel) are used.

The last two methods are usually employed in cases where, on account of the construction or size of the instrument, it is not advisable to reverse it very often; or, as in case of the Greenwich circle, where the instrument cannot be reversed at all.

As the greatest possible accuracy is sought with instruments of this class, it is especially desirable to vary the processes by means of which the instrumental constants are obtained. The various results derived, besides serving as a check on data otherwise obtained, furnish means for investigating irregular variations in the so-called constants, due to changes in the material of which the instrument is made.

The method which I am about to propose for finding the collimation constant, without reversing or disturbing the in-

strument, is believed to have some advantages over the ones already mentioned.

A light but rigid framework is hung from the pivots of the horizontal axis, the arms being of such a length that the telescope can be turned to the nadir. The whole arrangement being similar to a hanging level with this difference—in place of a level tube is substituted a plane mirror, securely held in such a position that when the telescope is pointed to the mirror the optical axis will be nearly normal to the reflecting surface.

With the aid of an adjusting screw one of the arms can then be lengthened or shortened until the middle transit wire and its reflected image are nearly in coincidence. The horizontal wire is then brought into coincidence with its reflected image by slightly rotating either the telescope or the hanging collimator about the horizontal axis.

Let $m_1$=the distance of the middle transit wire from its reflected image; positive when the image is on that side of the wire which is toward the clamp. $m_2$=corresponding distance after the *collimator* has been reversed. $c$=collimation constant —then

$$c=-\frac{m_1+m_2}{4}$$

The collimation constant is therefore positive (for clamp west) so long as the algebraic sum of the distances $m_1$ and $m_2$ is a negative quantity.

If the pivots on which the instrument rotates are not of the same diameter, the expression for $c$ will evidently become

$$c=-\left(\frac{m_1+m_2}{4}\mp p\right)$$

$p$ being the angle included between the axis of rotation and a rectilinear surface-element of the frustum of a cone having for bases those circular sections of the pivots which rest upon the wyes, the upper sign being used when the clamp pivot is the larger.

On account of the length of the arms of the collimator, inconvenience may be experienced in its reversal unless some changes are made in the castings through which the arms of the hanging level must pass before the instrument can be leveled. This seems to be the only objection that is likely to be raised against the practical application of the method to instruments now in activity. The film of silver, if kept properly covered when not in use, will last for years before resilvering will be necessary.

Ann Arbor, Mich., Jan. 8, 1883.

# SCIENTIFIC INTELLIGENCE.

## I. Chemistry and Physics.

1. *On metallic Thorium.*—Nilson has succeeded in preparing pure metallic thorium and in determining its properties. For this purpose he used potassium-thorium chloride, prepared by dissolving twice precipitated thorium hydrate in hydrochloric acid, adding two molecules sodium chloride for each one of the thorium chloride, and evaporating in a platinum dish. The dry residue was freed from moisture by heating nearly to ignition in a glass tube through which dry HCl gas was passed. A tube of wrought iron was used for the reduction. First a layer of pure dry sodium chloride was introduced, then the double chloride in alternating layers with sodium, pressed firmly down with a piston, and then more sodium chloride. The tube was closed with a screw cap and heated to a moderate red heat in a furnace. The reduction was completed in 15 minutes; and after cooling, the contents of the tube were treated with water, which left the reduced thorium undissolved. It appeared as a shining gray powder which under the microscope was seen to consist of small thin six-sided plates, the larger ones having the luster of nickel or silver, and being in some cases aggregated together. The crystals are brittle and in an agate mortar give a silver streak. Metallic thorium is permanent in the air up to 100° to 120°. Heated higher, it ignites even below redness, giving a brilliant light and forming snow-white oxide. Its attraction for oxygen is so great, that when heated under fused sodium chloride in a Schlösing's furnace for the purpose of melting it into a globule, it was entirely converted into oxide. It is therefore extremely difficult of fusion. It burns when heated in chlorine, bromine and iodine; but sulphur does not attack it at its boiling point. It does not decompose water at any temperature. Dilute $H_2SO_4$ attacks it, evolving hydrogen; strong $H_2SO_4$, with heat, evolves $SO_2$. Nitric acid dilute has a very weak action; strong, hardly any. Hydrogen chloride attacks it vigorously, evolving hydrogen. Alkali hydrates are without action. The specific gravity was found to be 11·0102, 10·9901 and 10·7824 in three samples. The first two specimens were from the bottom of the reduction tube, the third from near the top. This latter on examination was found to contain 19·4 per cent of oxide. Calculating this out, the specific gravity becomes 10·9178. —*Ber. Berl. Chem. Ges.*, xv, 2537, Nov., 1882. G. F. B.

2. *On the atomic weight of Thorium.*—Nilson has determined also the atomic weight of thorium. The raw material employed was Arendal thorite, of which 2 kilos. were at his disposal. The powdered mineral was gelatinized with hydrochloric acid, the silica removed by evaporation to dryness, the concentrated solution of the chlorides treated with hydrogen sulphide, filtered, treated with ammonia and decanted from the olive-green hydrate.

This after washing, was dissolved in HCl, precipitated with oxalic acid, the oxalates washed, dried and ignited, yielding 950 grams of a brownish-yellow earth. This was moistened with water and then treated with sulphuric acid which dissolved it completely. To obtain the sulphate pure the author took advantage of the fact observed by Berzelius, that the anhydrous salt was easily soluble, requiring 20 parts of water, while the hydrated salt required 88 parts; and further that the former must be preserved in ice-cold water, since on raising the temperature to 20°, the hydrated salt was deposited. The solution of the impure sulphate saturated at the freezing point was heated on the water bath to 20°; an abundant heavy snow-white crystalline precipitate of the hydrated sulphate came down, in amount about two-thirds of the total sulphates. On evaporation, the mother liquor yielded a second crop. By several repetitions of this operation, the sulphate was obtained pure. It was again precipitated with ammonia, the hydrate washed and dissolved in HCl, again precipitated and washed, again dissolved in HCl, converted into oxalate and ignited. The snow-white oxide was converted into sulphate and this was allowed to crystallize by the spontaneous evaporation of its solution. Large transparent brilliant crystals were thus obtained which were permanent in the air and had the composition $Th(SO_4)_2 . (H_2O)_9$. For the estimation of the atomic weight a weighed quantity of the pulverized salt was heated to expel its crystal water, again weighed, and then again heated to a full white heat. The sulphuric oxide was entirely expelled leaving pure thorium oxide which was again weighed. From the data thus obtained, the atomic weight was calculated. Assuming the quadrivalence of thorium, the values obtained were: 1st series, 232·40, 232·43, 232·32, 232·50, 232·39, 232·52; mean 232·43; 2d series 232·39, 232·38, 232·34, 232·38, mean 232·37.—*Ber. Berl. Chem. Ges.*, XV, 2519, Nov., 1882. G. F. B.

3. *On ethyl peroxide.*—Berthelot has examined the product of the action of ozone on ether. When a strongly ozonized current of dry oxygen is passed through anhydrous ether, the ozone is slowly absorbed and there remains a dense syrupy liquid, miscible with water, which is ethyl peroxide. It becomes viscous at −40°, but does not crystallize. Heated in a glass tube a portion distils; but the experiment was terminated by a violent explosion. Water decomposes it into alcohol and hydrogen peroxide, which may be separated by distillation. The aqueous solution acts like hydrogen peroxide, decomposing permanganate with effervescence of oxygen, converting chromic into perchromic acid. By the former reaction the author determined the active oxygen in the ethyl peroxide to be 11 per cent, and by the latter 10 per cent. The formula obtained is $C_8H_{20}O_3$ or $(C_2H_5)_4O_2$. The author calls attention to this as a ready means of forming $H_2O_2$.—*Ann. Chim. Phys.*, V, xxvii, 229, Oct., 1882. G. F. B.

4. *On Catechol-orthocarboxylic acid.*—Of the six acids having the formula $C_6H_2(OH)_2 . COOH$ which theory indicates, five have

already been produced. MILLER has now prepared the sixth, which has the carboxyl and the two hydroxyl groups in the positions 1 : 2 : 3 respectively, and which he calls catechol-orthocarboxylic acid. Two different methods were used: in the first, catechol (pyrocatechin) was heated with ammonium carbonate and water in a sealed tube to 130° to 140° for 14–16 hours. In the second, para-iodsalicylic acid was heated with an excess of potassium hydrate. It forms wart-like groups when anhydrous, melts and decomposes at 204°, gives a deep blue coloration with $Fe_2Cl_6$ which changes to violet-red with $Na_2CO_3$, is easily soluble in hot water, alcohol and ether, and gives with lead acetate a flocculent precipitate.—*J. Chem. Soc.*, xli, 398, Nov., 1882.

G. F. B.

5. *Conservation of Solar Energy.*—SIEMENS replies to the objections of G. A Hirn, Comptes Rendus, Nov. 6, 1882, and shows from the experiments of previous investigators that the temperature of the photosphere of the sun cannot far exceed that of the greatest electric light we can produce, and cannot be far, therefore, from 2800° C., and that the dissociation urged by Hirn would not take place. In regard to absorption in interstellar space, Siemens cites the experiments of Dr. J. W. Draper and of Professor Langley, and the opinion of many astronomers, that thousands of stars exist in space whose light is frittered away and never reaches the earth.

In regard to the mechanical resistance exerted by the gaseous matter which Siemens supposes to exist in space, Siemens cites the experiments of Mr. William Froude (British Association, 1875) in regard to the movements of solids in fluids. From which it is concluded that a submerged body moving with uniform velocity in a perfect fluid—that is, a fluid free from viscocity, in which no friction is caused by the gliding of its particles over each other or over the surface of bodies—would not meet with resistance of any kind. He applies this experiment to his theory, and strives to meet the objections of M. Hirn.—*Comptes Rendus*, No. 22, Nov. 27, 1882, pp. 1037–1043. J. T.

6. *Conservation of Solar Energy.*—M. G. A. HIRN replies to Siemens, and reiterates his opinion that the minimum temperature of the sun is 20,000° C., and that the dissociation to which he calls attention in his previous paper will occur. He also maintains his conclusions in regard to the density of the fluid filling interstellar space. The fraction $\frac{1}{10^{16}}$ kg. expresses a value of this density which, supposed to exist, would render the existence of planetary atmospheres impossible.—*Comptes Rendus*, No. 24, Dec. 11, 1882, pp. 1195–1198. J. T.

7. *Reduction of the Mercury Unit of Electrical resistance to absolute measure.*—E. DORN, by a modification of Weber's second method, used also by Kohlrausch, has obtained the following value: $1\ \text{S. E.} = 0{,}9482\ 10^{10} \frac{\text{MM}}{\text{sec}}$, where S. E. denotes the Siemen or

mercury unit.—*Annalen der Physik und Chemie*, No. 13, 1882, pp. 773–816. J. T.

8. *Approximate Photometric Measurements of Sun, Moon, Cloudy Sky, Electric and other artificial lights.*—Sir William Thomson having referred to the experiments of Pouillet, from which that author infers that the energy radiated by the sun is equal in British units to about 86 foot-pounds per second per square foot at the earth's surface, or about one horse power to every 6½ square feet of the earth's surface, proceeds thus in his calculation: Take, however, instead of the sun an ideal radiating surface of a solid globe of 440,000 miles radius. The distance of the earth being 93,000,000 miles, the radius of the sun is equal to, in round numbers, 1-200th of the earth's distance; hence the area at the earth's distance, corresponding to one square foot of the sun's surface, is equal to 40,000 square feet. The radiation on this surface is 40,000×86 or 3,440,000 foot-pounds, which is therefore the amount of radiation from each square foot of the sun's surface. This amounts to 7000 horse power, or 50 horse power to the square inch. The normal current through a Swan lamp giving a twenty-candle light is equal to 1·4 amperes with a potential of 40 to 45 volts. Hence the activity of the electric working in the filament is 61·6 ampere-volts or Watts (a Watt representing the unit of activity of the ampere-volt). To reduce to horse power we must divide by 746, and we then find about one-twelfth of a horse power for the electric activity in a Swan lamp. The filament is 3½ inches long and ·01 of an inch in diameter, of circular section; the area of the surface is thus 1·9th of a square inch, and therefore the activity is at the rate of three-fourths of a horse power per square inch. Hence the activity of the sun's radiation is about sixty-seven times greater than that of a Swan lamp per equal area. At the conference on Electrical Units which met in Paris lately, a suggestion was made to use as a standard for photometric measurements the incandescence of melting platinum, and very interesting results and methods in connection with the proposal were presented to the meeting. Sir W. Thomson prefers for approximate measurements Rumford's photometer to other photometers, and claims that with a reasonable amount of care measurements can be obtained within two or three per cent of accuracy. Arago has compared the luminous intensity of the sun with that of a candle and estimates it as equal to about 15,000 times that of a candle flame. Seidel estimated the luminous intensity of the moon as about equal to that of grayish basalt or sandstone. An experiment made on sunlight on the 8th of December, 1882, at Glasgow, compared with an observation on moonlight made by Thomson at York during the meeting of the British Association in 1881, has led him to conclude that the surface of the moon radiates approximately one-third of the light incident upon it. The observation on moonlight taken at York—about midnight at the time of full moon—showed that the moonlight was equal to the light of a

candle at a distance of 230 centimeters. The luminous intensity of a cloudy sky was found at 10 A. M., one day also at York, to be such that light from it, through an aperture of one square inch area, is equal to about one candle. An experiment on sunlight, Glasgow, Friday, Dec. 8th, 1882, showed at one o'clock that the sunlight was of such brilliancy that the amount of it coming through a pin-hole in a piece of paper of ·09 of a centimeter diameter produced an illumination equal to that of 126 candles. By cutting a piece of paper of such shape and size that it would just eclipse the flame of a candle, and measuring the area of the piece of paper, 2·7 square centimeters was found as the corresponding area of the flame. This is 420 times the area of the pin-hole, and therefore the intensity of the light from the sun's disc was equal to $126 \times 420$ or 53,000 times that of a candle flame. This is more than three times the value found by Arago for the intensity of the light from the sun's disc as compared with that from a candle flame.—*Electrical Review*, vol. xi, Dec. 23, 1882, p. 490. J. T.

9. *Dr. Siemen's Address to the Society of Arts.*—This address contains an interesting calculation of the cost of lighting large areas by electricity. The Parish of St. James in London was taken as an illustration. Its population, according to the census of 1881, was 29,865, it contains 3,018 inhabited houses, and its area is 784,000 square yards, or slightly above a quarter of a square mile. To light a comfortable house of moderate dimensions, to the exclusion of other methods of lighting, would require about 100 incandescence lamps of from fifteen to eighteen candle-power each, that being the number of lamps employed by Sir W. Thomson in lighting his house at Glasgow. Eleven horse power would be required to maintain these lights, and at this rate the Parish of St. James would require 33,200 horse power to light it. It has been proved that the lighting of the Savoy Theater requires 1,200 incandescence lamps, which represent the expenditure of 133 horse power; and about one-half that power would have to be set aside for each of the large public buildings in the parish, constituting an aggregate of 2,926 horse power; nor does this general estimate cover street lighting, and to light the six and a half miles of principal streets of the parish with electric light would require per mile thirty-five arc lights of 350 candle-power each, or a total of 227 lights. This taken at the rate of 0·8 horse power per light represents a further requirement of 182 horse power, making a total of 3,108 horse power for purposes independent of house lighting, being equivalent to one horse power per inhabited house, and bringing the total requirements up to 109 lights=twelve horse power per house. Assuming that the bulk of domestic lighting remains to the gas companies, and that the electric light is introduced into private houses only at the rate of twelve incandescence lights per house, the Parish of St. James would have to be provided with electric energy sufficient to work 63,378 lights=7,042 effective horse power; this is equal to about

one-fourth the total lighting power required. Siemens estimates the cost of the plant at £177,000. Electricity can be produced in London at about one shilling per 10,000 ampere-volts or Watts (746 Watts being equal to one horse power) per hour. Extending the St. James Parish calculation to the whole of London, Siemens estimates that to light it to 25 per cent of its total lighting requirement would require an expenditure of capital of £14,000,000, without including lamps and fittings, thus making an average capital expenditure of £100,000 per district. To extend the same system over the towns of Great Britain and Ireland would absorb a capital of £80,000,000. Siemens also estimates that the cost of lighting by incandescence is 21 s. 9½ d. per lamp for a year, while to produce the same luminous effects in a good argand burner costs 29 s. per year. This shows that lighting by incandescence is decidedly cheaper than lighting by gas. On the other hand, gas companies pay large dividends and can sell their gas at much cheaper rates than at present. Arc lighting is far cheaper than lighting by incandescence.—*Electrical Review*, vol. xi, Nov. 25, 1882, pp. 408–411. J. T.

10. *Die magneto-elektrischen und dynamo-elektrischen Maschinen und die sogenannten secundär-Batterien, mit besonderer Rücksicht auf ihre Construction dargestellt* von GUSTAV GLASER-DECEW. 263 pp. 12mo. Vienna, 1882 (A. Hartleben's Verlag).—This volume is the first of a proposed series of ten which are intended to form an electro-technical library. The titles of these volumes, as given in the prospectus, include all the important subjects involved in the practical applications of electricity, such as the transmission of power by electricity, electrical lighting and heating, galvanic batteries, telegraph, telephone, electro-plating and so on. The interest felt in all these subjects at the present time is so deep and wide-spread that a series such as this, if well carried through, cannot but be highly useful. Volume I of this series now published, discusses the various forms of magneto- and dynamo-electrical machines, dividing them however into two groups according as the currents generated are alternating currents, or of constant direction. The various forms of regulators, of secondary batteries, and so on, are also described; a theoretical discussion of the principles involved in the machines is given and then a statement of their various practical applications; a chapter on instruments for measurement is given in the Appendix. The descriptions in the book are clearly given, the illustrations are numerous and good; it presents in convenient form information which many persons are desirous of obtaining.

11. *A Treatise on the Distillation of Coal-Tar and Ammoniacal Liquor and the separation from them of valuable Products;* by GEORGE LUNGE, Ph.D., F.C.S. 8vo, pp. 383, London, 1882. (John Van Voorst).—The same qualities of accuracy, thoroughness and logical system, which distinguished the author's admirable "Treatise on Sulphuric Acid and Alkali," are found in the present work. It is not very long since coal tar was a waste

product, which the gas-manager was puzzled to dispose of. We quite well recall the time when it was taken out to the open sea and the casks containing it were thrown overboard for the want of any better use to be made of it. The researches of Hoffmann and Mansfeld (1845–47) on the light oils of coal tar and the preparation of pure benzene on a large scale, and, soon after, of nitro-benzene (Essence de Mirbane) as a substitute for the essential oil of bitter almonds, led the way to coal tar distilling on a limited scale; but the great impetus which this industry received was from the discovery of the aniline colors—aniline being derived exclusively from coal tar. From that date (1857) technical chemists have devoted much study to the investigation of coal-tar products, and science has been enriched by the discovery of many new hydrocarbons. Dr. Lunge's treatise is a model of what such a work should be. He handles the subject as only an original investigator can and not merely as a compiler. His main purpose is a clear and full explanation of the methods by which the various useful products existing in coal tar are separated. He does not encumber his book with the transformations and deviations of these products, that being the special work of the chemical manufacturer. The work is profusely illustrated by excellent wood-cuts, mostly to scale, of all the newest and best forms of apparatus in use in the business of the distiller of coal-tar products and the treatment of ammoniacal liquors. The best analytical methods for determination of purity and estimation of quantity are set forth with scientific accuracy. For the technical details, with which this treatise abounds, the reader interested in this line of chemical industry must consult the volume itself.

## II. Geology and Mineralogy.

1. *Note on Jointed Structure;* by W. J. McGee.—While collecting statistics of quarry industries in Iowa for the Tenth Census, during 1881, the writer made some observations bearing on the nature and origin of jointed structure. The rocks examined are mainly dolomites and pure or argillaceous limestones, and all exhibit more or less perfect jointing. Two classes of joints (differing only in width) are recognized by the quarrymen, viz: "clay seams" and "dry seams." The general type, as shown in fifty or more quarries, consists of two systems of "clay seams" crossing each other at large angles, with two systems of "dry seams" also crossing each other at large angles but approximately bisecting the angles formed by the principal systems. The phases presented are, however, quite variable: either of the two classes, or either system of either class may be absent, or additional and generally less conspicuous systems—sometimes so blending with the predominant classes as to separate the strata into either irregular or tolerably regular polygonal blocks—may be introduced; and the two classes pass imperceptibly into each

other. Moreover, the blocks themselves, in all rapidly deteriorating rocks, tend to break up on exposure (especially to frost) into prismatic fragments bounded by lines coincident or parallel with the jointage systems. There is every evidence that these jointage planes are superficial: In working downward or back from the face of the quarry the "dry seams" diminish in number and die out, and the "clay seams" attenuate and pass imperceptibly into "dry seams" which finally, in the deeper quarries, nearly or wholly disappear.

It was at first supposed that the phenomena could be satisfactorily explained by the contraction theories recently advocated by Kinahan (this Journal, last vol., p. 68), Crosby (Geol. Mag., viii, p. 416), and others; but from the judicial presentation of the whole subject by Gilbert (this Journal, last vol., p. 50) it appears that these theories are alone inadequate. It may therefore be suggested that the vertical compression and consequent lateral expansion of beds beneath areas of deposition may produce incipient slaty cleavage along certain lines perhaps determined by crystalline structure, and that the vertical expansion and consequent lateral contraction of the same beds when lightened by denudation, and subjected to cooling and desiccation, may develop such lines into jointage planes.

2. *The Climatic Changes of later Geological Times;* by J. D. WHITNEY. Part III, 265–394 pp. 4to. Cambridge, 1882. Vol. vii, No. 2, of the Memoirs of the Museum of Comparative Zoology at Harvard College.—In the preceding Part of Professor Whitney's work on "Climatic Changes of later Geological Times," noticed in a recent volume of this Journal,* the author stated his conclusion that a gradual diminution in the intensity of solar radiation had been the principal source of the change in the earth's climate, and that it went forward through the successive geological periods uninterruptedly, to the end of the Tertiary period. In Part III, he reaches the further conclusion that this gradual change was continued through the Glacial era to the present time, and that a warmer ocean for greater precipitation was the chief cause of Glacial conditions.

The author makes a comprehensive survey of the present distribution and limits of glacier regions, and of the facts illustrating their mode of formation, dealing especially with their dependence on the amount of precipitation. He thus considers the facts from South America, Asia, Europe, and the Polar regions, giving under the latter head a detailed account of the Greenland ice. He dwells at length on the oscillations in the extent of glaciers in the Alps and other glacier regions, and discusses the several explanations of these changes which have been offered. He points out, also, that even in Polar regions large areas are for part of the year without snow, and consequently without glaciers.

In the remarks on the climatic condition of the Glacial era, the facts reviewed are stated to sustain the propositions—now

* Vol. xxiii, p. 489; and Part I, in vol. xxi, p. 149.

generally accepted—that precipitation is one chief requisite for the formation of glaciers and for fixing their limits; and that a general glacial era for the whole earth at any one time is an impossibility; and also the following, about which there is general but not universal agreement, that a lower *mean* temperature than the present did not exist in the Glacial era.

The conditions of the Glacial era next come under consideration; and, on the basis of the facts, another proposition is sustained—now pretty generally admitted—that the ice of that era did not make a "polar ice-cap," and that the two large glaciated areas of the globe were that of Scandinavia and the surrounding country, and that of Northeastern America. He observes, with regard to the other areas of ice, that they were not on so grand a scale "as to make it necessary to admit the existence of conditions of climate or topography, or both, considerably different from those now prevailing over the same portions of the earth's surface." And, with reference to this subject, the facts respecting the present and former glaciation of these and other areas are considered at length, namely those relating to the former extension of the glaciers of the Alps, the Caucasus, the Himalayas, the Thian-Schan Mountains, the Altai and other regions. The review shows wide research, and is presented as favoring the conclusion that there was much less ice in those glacial areas than has been supposed to have existed, and not enough to make it appear that glacial conditions, or climates colder than now, were general even over the higher latitudes (north of 40° to 50°) of the Northern hemisphere.

Next, the limits of the two largest areas—those of Scandinavia and Northeastern America are considered, and with the same result in the author's convictions—that those who have investigated and discussed the subject, both European and American, have made the glacial areas very much larger than actually existed. After this review—which in all parts leaves a desire for more decisive facts, and for a fuller statement of some on record that have a different bearing, Professor Whitney announces as "most clearly" established, that "the Glacial epoch was a local phenomenon, during the occurrence of which much the larger part of the land-masses of the globe remained climatologically entirely unaffected;" that "a higher mean temperature was compatible with a greater extension of the glaciers;" that "there must be copious precipitation, which, although locally in the form of snow, can in reality be only the result of a high mean temperature in other regions;" that, in the words of Frankland in 1864, "the sole cause of the glacial epoch was a higher temperature of the ocean than that which obtains at present" (a view which, as Professor Whitney states in a note, Professor Frankland modified in 1877 so as to make simply "a high temperature of the surface of the sea a necessary condition of the Glacial epoch"); that there has been "a progressive diminution of the temperature on the earth's surface during the geological ages, and from the very

earliest time when land began to exist from the conditions of which light on this subject could be procured."

The physical conditions producing the warmer sea are not considered by Professor Whitney, nor those by which a warmer ocean—from whose area would come warm winds as well as excessive precipitation—occasioned the extensive glaciation of which there is abundant record even in California and Colorado as well as in other colder countries. The argument for narrower limits to the glacial regions than have been laid down, which for Northeastern America is made up more of supposed reasons for doubts than of positive facts of personal observation, can be best met by a new reference to the accounts of original investigators, and by the collection of new facts in this direction. The writer will present the results of a study of the "New Haven region" in an early number of this Journal.

The author does "Professor Dana" much more than justice in the remark that "his authority is almost exclusively followed by the younger workers in Geology in this country;" for, in connection with this subject of the Glacial era, the various State geologists, younger or not, have had knowledge and judgment enough to gather extensive ranges of facts from over the country, east and west, and put forth their well-labored conclusions for his and others' acceptance; and they are leading him onward still further to deductions with respect to the "terminal moraine" or southern limits of the ice, extending from Long Island through New Jersey, Pennsylvania and other States, to Minnesota. Professor Whitney points out that the writer has greatly changed his opinions with the progress of the science by quoting, in a note referring to his recent views, the views he held in 1863. The writer is open to further changes of opinion where new facts may require them; and he will have some to present in the forthcoming article.

J. D. D.

3. *Tenth Annual Report of the Geological and Natural History Survey of Minnesota;* for the year 1881. N. H. Winchell, State Geologist. 254 pp. 8vo, with three fine maps and several plates. St. Paul, Minn., 1882.—Professor Winchell presents in this Report an important discussion with regard to (1) the *age of the Keweenaw cupriferous red sandstones, shales and conglomerates;* (2) *the light-colored horizontal sandstones of the south shore of Lake Superior in Wisconsin, holding Fucoids and Scolithus; and* (3) *the St. Croix sandstone containing Lingulæ and Trilobites.*

After a comparison of the rocks and their fossils with those of the Potsdam and Calciferous of the Eastern United States, he derives the conclusions: that all three are of Lower Silurian; that the oldest group of the vicinity of western Lake Superior is the Animikie group of Hunt, which includes slates, quartzyte and some dolomite, and which on the northwest shore of Lake Superior, in Thunder Bay, carries ores of silver; and that it is probably Acadian (Menevian) in age; that this formation is

overlaid by the Cupriferous (No. 1, above), and "so far as evidence goes it appears in Minnesota to graduate into this overlying formation conformably;" that the overlying Nos. 2 and 3, which consist of horizontal light-colored siliceous sandstones with some dolomitic layers near the top, and at some points lie unconformably on the tilted copper-bearing rocks (No. 1), and whose many fossils (including among the Trilobites 6 species of *Dicellocephalus*, 8 of *Conocephalites*, 3 each of *Ptychaspis* and *Agnostus* and others), show a relation in age to the Quebec group, though cautiously assigned to the Potsdam period by Hall. Professor Winchell is hence disposed to consider the St. Croix sandstone of the age of the Quebec group. [At present it seems probable that the Quebec group in the east will ultimately become divided between the Calciferous and Chazy.] The red sandstone formation of Keweenaw is stated to be "locally changed to gneiss, syenyte, and hard red quartzytes, as well as interbedded with doleryte and mixed with gabbro."

Professor Winchell also states on page 112, in connection with a description of Minnesota rocks, that about Beaver Bay a red conglomerate occurs changed to red syenyte; and that the altered rock was in a plastic state, as shown by its running in belts and veins through the trap and the associated feldspar rock. "The feldspar masses are geologically from the same rock as the Rice Point gabbro, and both are the result of copious, and perhaps one of the earliest, igneous outflows of the Cupriferous."

The Report also contains descriptions and figures of some freshwater Entomostracan and other Crustaceans of Minnesota, by C. C. Herrick. Two species of Decapods are mentioned as occurring in the rivers of the State, *Cambarus virilis* Hagen, and the species, here first described and named, *C. signifer*.

*Flooded Lake Winnipeg.*—In the prefatory "summary statement" of the Report, a notice is given of the present views of Mr. Warren Upham with regard to flooded Lake Winnipeg, to which, as stated on page 433 of the last volume of this Journal, he has given (unfortunately we think) the name Lake Agassiz. Mr. Upham makes the lake to have covered not merely the Red River prairie region of læss (which bears evidence of lacustrine conditions), as stated by General Warren and others, but to have spread far eastward of this limit over the upper prairie (which is characterized by coarse deposits such as mark fluvial and drift conditions); and to have probably covered Red Lake under 50 or 100 feet of water, Lake of the Woods under about 200 feet, the Red River Valley at St. Vincent 450 feet, and Lake Winnipeg *about* 600 *feet*." The evidence referred to as supporting this conclusion consists in "beach lines," of which there are three. The evidence that these supposed beach lines were of lacustrine origin and not fluvial is not given in this brief summary.

In explanation of the conditions of water-level it is stated that the beaches "have been ascribed to the operation of the glacial period in the epoch of its decline, when the ice still existed to the

north to prevent northern drainage. The same obstruction [the ice] must have existed in the Red River Valley, and, in the opinion of Mr. Upham, *its attraction was sufficient to move the mass of the water toward itself, and to cause an ascending shore line in that direction.* Any such barrier, operating inversely as the squares of its distance from different parts of the lake, would thus cause a more rapid ascent in those portions of the shore line near it than in those more remote." But the barrier of ice, even if 2,000 feet thick, would have been equivalent in mass to less than an 800-foot layer of rock; and the rise against such an ice-barrier at Lake Winnipeg would have been, if the water extended 300 miles to the southward, not over fifty feet—giving to the shore-line of the great lake a slope very different from what observations show to have been the fact. While such conditions (the surface being still *level*) help nothing the southward flow, they make deeper water near the barrier, and hence would increase the tendency of flow northward beneath the ice. J. D. D.

4. *Geological Survey of Pennsylvania.*—This Report of the Board of Commissioners to the Legislature, dated Jan. 1, 1883, states that the survey of the State, both geological and topographical, is mostly completed, only a few areas remaining, the study of which will occupy the year 1883. The work has gone forward with great energy under the direction of Professor Lesley, and with remarkable promptness in the publication of the Reports on the work of each year, all of which have been carefully prepared, and are essentially final Reports. The chief work remaining is the special underground as well as above-ground survey of the Anthracite region, which has been in progress for eighteen months. As the object of the Anthracite survey is to make an exhibit of the structure, position and thickness of coal-beds and associated rocks, with that completeness of underground detail that will render the maps and sections an aid and guide to the coal-worker of the future as well as present time, the progress of the survey is necessarily slow. Three years more will complete it; and as the anthracite industry "has contributed to the State, directly and indirectly, millions of dollars in taxation," the amount required for three more years is confidently looked for from the Legislature.

5. *Permian Plants of Colorado.*—In the red-beds of South Park, Colorado, near Fairplay, a shale contains, besides remains of insects, scales, seeds and leaves of Conifers, a stem of a Lepidodendron and remains of Ferns. Professor L. Lesquereux, to whom the specimens were sent by Professor Scudder (which were partly of his collection but in part from the Museum of Comparative Zoology), has examined the plants and found that among the species there are the following which are characteristic of the Permian: *Ullmania frumentaria* Göpp., *U. selaginoides* Gein., *U. Bronnii* Göpp., *Walchia piniformis* St., *W. longifolia* Göpp., a species of *Abietites*, *Callipteris conferta* Weiss, *Odontopteris obtusiloba* Naum., *O. cordata* Göpp., *Cyclopteris rari-*

*nervis* Göpp., *Sphenopteris Geinitzii* Göpp., *Hymenophyllites Leuckarti* Gein., a species of *Schizopteris.*—*Bull. Mus. Comp. Zool.*, Cambridge, Mass., vol. vii, No. 8.

6. *Nummulitic deposits in Florida.*—Specimens of a white or yellowish-white friable limestone, from the vicinity of the Cheeshowiska River, Hernando County, four miles from the coast, consist chiefly, according to Mr. ANGELO HEILPRIN (Proc. Acad. Sci. Philad., 1882, p. 189) of Nummulites of the genus *Nummulina.* They are of one species which he names *N. Willcoxi*, from its discoverer Mr. Joseph Willcox. It is remarkable, as stated by the author, that the accompanying fossil mollusks are of species more recent than Eocene, even *living species of fresh-water genera*, viz: *Glandina parallela, Paludina Waltonii, Ampullaria depressa.* But the genus, *Orbitoides*, which had its largest development in the Upper Eocene, is also present, indicating, with "little or no doubt," that the rock fragments "derived their faunal character from deposits of a more ancient formation," either Eocene or Oligocene; and the original beds may possibly be now submerged.

7. *Lapparent's Traité de Géologie.*—The last part of this very valuable work, extending it to 1280 pages, has just been issued.

8. *Pot-holes in the Bronx Valley, Westchester County, New York.*—In the Transactions of the New York Academy of Sciences, No. 8 of vol. i, May, 1882, Dr. N. L. BRITTON describes large pot-holes in fine-grained gneiss, west of the Bronx, two to three miles north of Williams Bridge. One, about 9 feet deep and 10 feet in diameter at middle, is at bottom 18 feet above the present level of the stream; and another about 10 feet deep is 20 to 22 feet above.

9. *Sulphur deposits at Cove Creek, in Millard County, Southern Utah.*—The publication cited from in the preceding paragraph contains a note by Mr. I. C. RUSSELL on the Sulphur deposits of Cove Creek. At this place fifteen mines have been "located," a few of which have been developed to a slight extent. At one place the sulphur occupies a nearly extinct solfatara; at others it impregnates and cements beds of tufa, or lines fissures with crystals. Two miles south of the fort at Cove Creek the solfatara occupies nearly a circular crater 1200 feet in diameter, and at its center the impure sulphur has a depth exceeding 25 feet. Sulphur depositions are still in progress from escaping vapors.

A mile north of Cove Creek, at the Philadelphia Mine, a fissure in trachyte is lined with sulphur crystals; and at the Mammoth Mine, fissures and openings in dark-colored Carboniferous limestone. A volcanic cone southwest of Cove Creek stands on the Mammoth Mine line of fracture and faulting.

The deposit of gypsum associated with the sulphur is sometimes eight feet thick, and those of alum, two feet. Hot springs occur in the same region.

10. *On some minerals from the sodalite-syenite in the Julianehaab district in South Greenland.*—The sodalite-syenite and as-

sociated minerals occurring on both sides of the Tunugdliarfik and Kangerdluarsuk fiords in southern Greenland have been recently studied by J. LORENZEN of Copenhagen. The chief constituents of the rock are a greenish-white feldspar, arfvedsonite (and ægirite) and sodalite; there also occur eudialyte, nephelite, lepidolite, ænigmatite, and a new mineral called steenstrupine; also at one spot ilvaite with calcite, and finally some zeolites, in particular analcite and natrolite. It is noted as a point of special interest that the association of minerals is very closely the same as that observed in the syenite of Langesundsfjord in southern Norway. The author gives the results of careful analyses of the arfvedsonite, ægirite, sodalite, nephelite, eudialyte, ilvaite and lepidolite. The mineral called steenstrupine is named after Mr. K. J. V. Steenstrup of the Danish Geological Survey of Greenland. It occurs massive, also in indistinct curved crystals, the edges and planes appearing as if gnawed. Rarely the crystals admitted of partial determination; they were concluded to be combinations of the basal plane with one or two + rhombohedrons and perhaps a − rhombohedron; for the angle between the basal plane and the fundamental rhombohedron was obtained 128° approximately. The color is brown, streak nearly white. Hardness =4, specific gravity =3·38. It fuses rather easily before the blowpipe to a gray dull bead. An analysis yielded:

| $SiO_2$ | $Ta_2O_5$ | $Fe_2O_3$ | $Al_2O_3$ | $ThO_2$ | MnO | CeO | $LaO, DiO$ | CaO | $Na_2O$ | $H_2O$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27·95 | 0·97 | 9·71 | 2·41 | 7·09 | 4·20 | 10·66 | 17·04 | 3·09 | 7·98 | 7·28 | =98·38 |

No attempt is made to calculate a formula since more analyses are needed to establish the chemical composition.

11. *A Treatise on the Metallurgy of Iron, etc.;* by A. BAUERMAN, F.G.S. 5th edition, revised and enlarged. 515 pp. London, 1882 (Crosby Lockwood & Co.).—This excellent little book is now so well-known that it needs no extended notice. The fifth edition, recently published, includes considerable additions, discussing especially the Siemens and Bessemer processes for the manufacture of steel; notices of important deposits of iron ores in Spain, northern Africa and elsewhere have also been given.

12. *Materialien zur Mineralogie Russlands*, von N. VON KOKSCHAROW. Vol. viii, pp. 331–432. St. Petersburg, 1882.—Volume viii of Professor Kokscharow's great work on the Mineralogy of Russia is completed by the one hundred pages recently published. The species discussed are: analcite, vauquelinite, aragonite, chiolite, chodneffite, vauquelinite (and laxmannite, the two being shown to be identical), chrysolite, wulfenite, amphibole (nephrite) mica, rhodizite, crocoite, perofskite, pachnolite. Of these species, vauquelinite and wulfenite are treated to extended monographs; the descriptions of the others are supplementary to monographs which have appeared in some earlier part of the work.

13. *Notes from the Laboratory of the University of Virginia.* —Recent numbers of the Chemical News have contained a con-

tinuation of Notes of Work by Students in the Laboratory of the University of Virginia, under the charge of Professor J. W. Mallet. The following analyses are extracted. An analysis of *allanite* from Bedford Co., Va., by W. T. Page, yielded:

| $SiO_2$ | $Al_2O_3$ | $Ce_2O_3$ | $Di_2O_3$ | $La_2O_3$ | $Fe_2O_3$ | FeO | BeO | MgO |
|---|---|---|---|---|---|---|---|---|
| 26·70 | 6·34 | 33·76 | 16·34 | 1·03 | 3·21 | 4·76 | 0·52 | 0·54 |

| CaO | $Na_2O$ | $K_2O$ | $H_2O$ MnO |
|---|---|---|---|
| 2·80 | 0·49 | 0·55 | 1·99, tr.=99·03 |

The specimen was black, compact with pitch-like luster; specific gravity 4·32. It is remarkable for the high percentage of the cerium metals, more especially of didymium.

The *helvite* from near Amelia Court House, Va., has been analyzed by B. E. Sloan, with the following results:

| $SiO_2$ | BeO | MnO | FeO | $Al_2O_3$ | Mn | S |
|---|---|---|---|---|---|---|
| 31·42 | 10·97 | 40·56 | 2·99 | 0·36 | 8·59 | 4·90=99·88 |

Specific gravity 3·25. The material analyzed was pure, consisting of fragments of tetrahedral crystals; the analysis consequently represents more nearly the composition of the species than the earlier one by R. Haines, (this Journal, xxiv, 155).

Grains of *metallic iron* accompanying native gold in Montgomery Co., Va., have been investigated by W. T. Page. They occur in the alluvial washings in the bed of Brush Creek; the largest weighed 60 to 80 milligrams, the smallest were almost dust, the average weight being 5 milligrams. Some of the grains were rounded but many are flattened scales, often twisted, with rough ragged edges. Specific gravity 7·20. It is regarded as reasonably certain that these grains are really native iron. An analysis gave:

| Fe | Cu | S | Quartz. |
|---|---|---|---|
| 97·12 | 0·04 | 1·47 | 0·82=99·45 |

Similar grains, according to the same observer, occur in the auriferous sands of Burke Co., N. C.

An analysis of colorless *mimetite* in slender hexagonal crystals from the Richmond mine, Eureka, Nevada, afforded F. A. Massie:

| $As_2O_5$ | $P_2O_5$ | PbO | $PbCl_2$ |
|---|---|---|---|
| 23·41 | tr. | 68·21 | 8·69=100·31. |

Analyses are given of fergusonite from Brindletown, N. C., of altered samarskite ("euxenite") and of allanite (orthite) from Mitchell Co., N. C., all by W. H. Seamon; these analyses have already been quoted in this Journal, but without the name of the analyst.

A mineral from the Great Eastern Mine, Park Co., Colorado, has been analyzed by W. T. Page, which proves to be allied to bournonite and stylotypite, having the same general formula. It had a crystalline structure, a steel-gray color and dark-red streak. Specific gravity 4·89. The analysis gave:—

| S | Sb | Cu | Zn | Fe | Pb | gangue. |
|---|---|---|---|---|---|---|
| 26·88 | 34·47 | 23·20 | 7·14 | 1·38 | 1·19 | 5·86=100·12 |

The copper is stated to be present, one-half as cuprous, one-half as cupric sulphide.

*Native Palladium Gold,* from Taguaril, near Subara, Minas Geraes, Brazil, has been analyzed by W. H. SEAMON, containing 8·2 per cent palladium; specific gravity 15·73, the color was dark or bronze-like.

14. *Analyses of Danburite from Switzerland.*—The occurrence of danburite on the Skopi, Switzerland, has already been noticed. The following analyses, 1 by Schrauf, 2 by Bodewig, (Z. Kryst., vii, 391) show that it corresponds exactly with the American mineral.

| | | $SiO_2$ | $B_2O_3$ | CaO | $Fe_2O_3$, $Al_2O_3$ | ign. | |
|---|---|---|---|---|---|---|---|
| 1. | | 48·92 | [26·88] | 21·97 | 1·87 | 0·36 | =100·00 |
| 2. | ($\frac{a}{2}$) | 48·66 | 28·09 | 22·90 | 0·23 0·08 | --- | =99·96. |

15. *Native Lead and Minium in Idaho;* by W. P. BLAKE. (Communicated).—These comparatively rare species are found together in the midst of masses of galenite at the Jay Gould Mine, Alturas County, Idaho Territory, not far from Bellevue. The metallic lead is in small rounded masses or grains from an eighth to one-quarter of an inch in diameter, and sometimes in irregularly reniform bunches, weighing an ounce or more. The red oxide is in the form of coatings or crusts on the metal. Neither are abundant.

16. *Topaz from Stoneham, Maine.*—At the meeting of the New York Academy of Sciences, held Nov. 7th, 1882, Mr. G. F. Kunz announced the discovery by him at Stoneham, Maine, of topaz in fine and large crystals, in habit resembling the Russian. The largest of the more transparent ones measured about three inches in the direction of the macrodiagonal, and two and one-half parallel to the vertical axis. The color is of a bluish and greenish tint. Some of the large opaque masses were parts of crystals measuring one foot across. Associated with these were damourite, triplite, triphylite, columbite; one mass of the latter weighing over seventeen pounds, and the pink mineral (montmorillonite ?) described by Brush and Dana as occurring at Branchville, Conn.

## III. BOTANY AND ZOOLOGY.

1. *On the occurrence of Formic and Acetic Acids in Plants, and their physiological importance in Metastasis ;* by Dr. E. BERGMANN. (Bot. Zeit., Oct. and Nov., 1882.)—Since the detection of acetic acid in plants by Fourcroy and Vauquelin in 1809, and of formic acid by Döbereiner in 1831, these substances have been found in many species of plants. Availing himself of a modification of the silver method as a test for the latter acid, Dr. Bergmann has examined a large number of plants for the purpose of determining under what conditions the acids are formed and what part they play. His results are briefly summarized as follows:

(1.) Formic and acetic acids occur in protoplasm throughout the

whole vegetable kingdom. They are found in the most widely different parts of plants, and are present both in plants which contain chlorophyll and in those which are devoid of it.

(2.) They are constant products of metastasis in vegetable protoplasm.

(3.) It is probable that other members of the series of volatile fatty acids (propionic, butyric, caproic and perhaps the whole series) have a very wide diffusion throughout the vegetable world.

(4.) There is an increase in the amount of volatile acids in a plant in which assimilation has been arrested by withdrawal of light, and in which the state of inanition has supervened.

(5.) Formic and acetic acids are probably produced by retrograde metamorphosis.

(6.) In a plant subjected to a temperature below that of the minimum of growth, and at the same time deprived of light, there is no increase in the amount of volatile acids.

(7.) The formation of these acids appears therefore to be somehow independent of the respiratory process.

(8.) In all probability they result from the splitting up of constituents of vegetable protoplasm. G. L. G.

2. *Conspectus Floræ Europææ, seu Enumeratio Methodica Plantarum Phanerogamarum Europæ Indigenarum, indicatio distributionis Geographicæ singularum*, etc. Auctore Carolo Frider. Nyman. Orebro Sueciæ, 1878–1882, pp. 858, 8vo.—We have noticed the three earlier parts of this work, and may now announce its completion. It is the best substitute for that *desideratum*, a Flora of Europe, and, from its compactness, extremely useful even if we had such a Flora. Dr. Nyman hopes to bring out a Supplement, to contain later discoveries, in which he will give the Ferns and their allies, perhaps the *Characeæ* also. He will add, likewise, a full index of species and synonyms, which has been prepared for the present volume, but was omitted for want of room. A. G.

3. *Flora Brasiliensis.*—Dr. Eichler has made progress with this great work since our last announcement. We now have fasc. 86, in which Dr. Drude completes the *Palmæ;* fasc. 87, containing the Asteroid and Inuloid *Compositæ*, by Mr. Baker of Kew; and the thin fasc. 88, containing the *Haloragee* by Dr. Kanitz, of Klausenburg. The first and the last of these terminate volumes. A. G.

4. *Flora of British India*, part IX.—This part completes the third volume (*Caprifoliaceæ–Apocynaceæ*), of 708 pages, 1880–1882, and being issued at the close of the latter year, shows good progress. The greater portion of this part (*Vacciniaceæ* to *Salvadoraceæ*) is the work of the indefatigable and acute C. B. Clarke; the large and difficult order *Apocynaceæ* by the editor, Sir J. D. Hooker. Among the Gaultheria-like *Ericaceæ* is a *Diplycosia? semi-infera.* The American *Chiogenes*, put in *Vaccineæ* on account of its technical character, though otherwise Gaultheria-like, has its ovary half or two-thirds inferior; all going

to show that the *Vaccinieæ* should rank only as a suborder of *Ericaceæ*. A. G.

5. *Causes determining the Distribution of Oceanic life in depth.*—Prof. T. Fuchs has published an important paper on this subject in the Vienna Geological Verhandlungen, No. 4, for 1882.* He arrives at the conclusion that while *temperature* is a chief cause of the distribution of littoral species, *amount of light* is the prominent limiting cause in depth; and that this cause determines the limit between "that which we distinguish as a littoral fauna and a deep-sea fauna;" in other words, "*that the littoral fauna is nothing but the fauna of light, and the deep-sea fauna the fauna of darkness;*" and that this is true also for the main part in fresh water lakes.

Prof. Fuchs remarks that the limit to which light penetrates downward, according to Secchi, Pourtales and Bouguer, is 43 to 50 fathoms, but saying, in view of the occurrence of nullipores at 180 fathoms, that a feeble amount may penetrate farther; and after a wide survey of facts from the ocean he arrives at this depth as that of the boundary between the two faunas; the *deep-sea* fauna becoming very abundant, the world over, below this limit, and especially at about 90 to 100 fathoms, as shown in the deep-sea corals, echinoderms, and other species;† while much the larger part of the littoral species are confined within 30 fathoms of the surface. The following table presents some of the facts:

| | Deep-sea Corals. | Brachiopods. | Authorities. |
|---|---|---|---|
| Norway | 60 fathoms. | 30 fathoms. | M'Andrew and Barrett. |
| English Coasts | 50 | | Forbes. |
| Bay of Biscay | 31 | 31 | Fischer. |
| Mediterranean | 50 | 50 | |
| Florida | 40 | | Pourtales and Agassiz. |
| Brazil | 30–40 | | Hassler Expedition. |
| Philippines | 40 | | Semper. |
| Cruise of the Gazelle | 40 | | Studer. |

The passage from one fauna to the other occurs between 30 and 90 fathoms; but at the same time there is in the tropics below the 30-fathom line an extremely sterile region with few animals, that continues to a depth of about 80 or 90 fathoms, which intermediate sterile zone is unknown in the temperate and colder seas. Vitreous sponges occur most abundantly at 90 to 100 fathoms. Those of the Philippines live at depths not below 100 fathoms, and several species occur near Barbadoes, between 80 and 100 fathoms, along with numerous species of deep-sea corals and some crinoids.

* Verhandlungen der k. k. geologischen Reichsanstalt, 1882, No. 4, pp. 55–68; and, translated (by W. S. Dallas), in the Ann. Mag. Nat. Hist., for January. The above abstract is made from the latter.

† The following are enumerated as the most characteristic types of the deep-sea: Of corals, Oculinidæ, Cryptohelia and various solitary species; the Vitreous sponges; Crinoids (Pentacrinus, Rhizocrinus, Hyocrinus, Bathycrinus); of Echinoids, Echinothuriæ, Pourtalesiæ, Ananchytidæ; of Asterioids, Brisinga; Holothuriæ of the sub-order Elasmopodia; Fishes, ribbon-like in form, of the families Lepidopidæ, Trachypteridæ, Macruridæ and Ophidiidæ.

To the common observation that surface arctic species extend along the cold depths of the ocean toward the equator and the antarctic seas, Prof. Fuchs says that these arctic species are few and not characteristic kinds; and that some are not littoral species, but from the deep-sea as elsewhere.

Prof. Fuchs speaks of the abundant life in the arctic seas notwithstanding the coldness of the waters, the temperature ranging between 28° F. and 35° F.; of a temperature suitable for tropical species (70° F.) in the Red Sea down to a depth of 600 fathoms, and yet, as far as known, the littoral species do not extend deeper than in other seas; of vitreous sponges, deep-sea corals, Brachiopods, etc., living, between Norway and Iceland, in waters having a temperature between 30°·2 and 28°·4 F.; of similar kinds, and many of them the same in species, occurring at the same depth off Scotland and Ireland, in waters 43° to 48° F. in temperature; on the Pourtales Plateau, in waters at 44° to 56° F.; and on the Euplectella grounds near the Philippines, in waters at 59° F. (Semper), and off the island of Cebu, in 69°·8 F. (Moseley.) The statement of these and other facts, unfavorable to the idea that temperature is the cause of limitation in depth, he prefaces by the remark that "Dana has already repeatedly and emphatically pointed out that temperature plays only a very subordinate part in the distribution in depth of sea-animals;* and the facts which may be cited in favor of this are of so convincing a nature that one cannot help wondering how such an opinion, as the above, could so long prevail."

Prof. Fuchs observes further that *pelagic* species, or those of the open sea, are really *species of the darkness;* that they come up to the surface as the light fades away into night, and return with approaching day; that, like the deep-sea species, many of them have the deep-sea feature of phosphorescence, fitting them for life in the darkness.

Prof. Fuchs queries also whether some littoral species which extend down to great depths, may not be species that hide themselves during the day in dark places, or shut themselves up in their shells; and whether true deep-sea species may not often occur mixed with the littoral in the cavernous recesses about coral reefs and on other shores; and suggests to the geologist the importance of this consideration, as is also the fact that the dark sea-depths exist at only 50 fathoms. In this connection he states that the blind Isopod of the genus *Cœcidotœa* (*Asellus Borelli* is referred here by Cope and Packard), occurs in the great depths of Lake Geneva, as well as in the American and Carniolian caves; and that while the Ophidiidæ (near allies of the Gadidæ) are the most abundant and characteristic kinds of deep-sea fishes, and several of them are blind, there is the remarkable fact that two blind Ophidiidæ, showing close resemblance to their deep-sea relations, occur in the caves of Cuba.

* This Journal, vol. xv, p. 264, 1853. Also, Exp. Exp. Report on Zoophytes, 1846, p. 103, Report on Geology, 1849, p. 97, and Report on Crustacea, 1852, p. 1485.

With regard to the littoral region, Prof. Fuchs points out that there are three prominent assemblages of species: (1.) the seaweed areas, which do not reach down below 30 fathoms, and are very abundant in species; (2.) the coral-reef areas, not passing the limit of 20 fathoms, which are "the gathering grounds of an extremely rich fauna," and so peculiar that the terms coral-fishes, coral-mollusks, etc., would not be inappropriate; a fauna that embraces "the whole splendor of the animal life" of the Indian and Pacific Oceans; and (3.) the areas of large bivalves such as oysters, pearl oysters, scallops, which have their maximum development in from 8 to 10 fathoms and are not found below 20 fathoms. Each of these groups must have their limit fixed by the amount of light they require.

Prof. Fuchs does not speak of the effects of temperature carried over portions of the sea bottom by great oceanic currents from the north and south, and the division consequently of the deep-sea fauna in those parts into a warmer and colder, characterized by some difference in genera and species, this being outside of his special subject.

## IV. Astronomy.

1. *Parallax of Alpha Lyræ and of* 61² *Cygni.*—In a memoir which is to form one of the appendices to the Washington Observations, Professor Hall has given in full his observations upon the above two stars made between May, 1880, and December, 1881, with the large refractor. An account of this work was given to the American Association at Montreal. The measurements were in each case those of differences of declination with neighboring small stars. They were uniformly in sets of eight, and were made on 77 and 66 nights respectively.

The resulting parallax is deduced for $\alpha$ Lyræ for each of the two kinds of illumination separately. For dark lines on a bright field sixty-nine sets of observations give a parallax of $0''{\cdot}1556 \pm 0''{\cdot}00764$; for fifty-nine sets with bright lines on a dark field, $0''{\cdot}2080 \pm 0''{\cdot}00827$. The combined result by weights is

$$\pi = 0''{\cdot}1797 \pm 0''{\cdot}005612.$$

This parallax is differential with the small 10th magnitude companion nearly south of Vega. Assuming this star's parallax to be insensible, the time required for light to pass from Vega to our sun is 18·11 Julian years. The differences of declination were a little greater as measured with bright wires than with dark ones.

Only the first kind of illumination was used for 61² Cygni. The result from sixty-six sets of observations gives for the parallax as compared with D. M. +38°, No. 4345 (a star of the 9·5 magnitude, about 3′·3 south of the double star)

$$\pi = 0''{\cdot}4783 \pm 0''{\cdot}01381.$$

The corresponding time for light to pass from this star to our sun is 6·803 Julian years. The color correction of the Washington

refractor seems to be better adapted to the color of $\alpha$ Lyræ than to that of 61² Cygni, and this may be a reason why the probable error is larger for the latter determination.

There are no stars which have been so frequently and withal so carefully investigated for parallax as Vega and 61² Cygni. It may be interesting to place alongside of Professor Hall's elaborate determinations other published values of the parallaxes of the same stars.

| $\alpha$ Lyræ. | ″ | 61² Cygni. | ″ |
|---|---|---|---|
| F. Struve | 0·261 | Arago | 0·55 |
| C. A. F. Peters | 0·105 | Bessel | 0·88 |
| C. A. F. Peters | 0·142 | Bessel | 0·348 |
| Johnson | 0·14 | C. A. F. Peters | 0·349 |
| O. Struve | 0·119 | C. A. F. Peters | 0·360 |
| O. Struve | 0·161 | Pogson | 0·384 |
| Maln | 0·154 | Johnson | 0·397 |
| Brünnow | 0·212 | Woldstedt | 0·523 |
| Brünnow | 0·131 | O. Struve | 0·509 |
| Hall | 0·1556 | Anwers | 0·564 |
| Hall | 0·2080 | Hall | 0·4783 |

The excellence of the observations, the character of the instrument, and the carefulness and skill of the reductions, seem to justify our having unusual confidence in Professor Hall's work and results. H. A. N.

2. *Orbit of the Comet of* 1771.—Only a few of the comets that have been well observed have had a hyperbolic path assigned to them in the best definitive determination of their orbits. The comet of 1771 had, as computed by Encke, an ellipticity of 1·009368. This, though in itself not greatly different from unity, is yet larger than is usual in the few assigned hyperbolic orbits. The comet was visible for three months and through an arc of 132°. It has, therefore, been regarded as the best established instance of such a path. Encke used only six selected observations, and with his hyperbolic orbit gave also a parabola which satisfied them within reasonable errors of observation, though not as well as the hyperbola.

The question whether observations ever require us to accept the hyperbola as an actual form of orbit for any comet is of special interest. Professor W. Beebe undertook a full discussion of all the observations of this comet, to determine whether they would give the same result as the six used by Encke, whether the perturbations by the planets would modify the results, and whether any effect, and if so what effect, would be caused by reasonable variations of the later observations made at Marseilles, which were in any case subject to large errors. The results of his discussion were published in vol. v, pp. 159–176, of the Conn. Academy's Memoirs (1879). Professor Beebe concludes that hyperbolic elements (ellipticity=1·005901) should be taken as the best definitive elements of the orbit, and that while the parabolic residuals are not large enough to render the supposition of such an orbit untenable, the balance of probability is still with the hyper-

bola. He also expresses his strong belief that the difference between the residuals from the hyperbolic and from the parabolic elements can be but little reduced by any supposition of error in the Marseilles observations.

In the Vierteljahrschrift for 1881, Dr. Schönfeld discusses the memoir of Professor Beebe, points out some corrections that should be made, and expresses the belief that the original records of the observations are in existence, and can be used for the further discussion of the question.

On the 12th of October last, Professor Weiss communicated to the Vienna Academy the results of a new computation by Dr. Kreutz. In the notice in the Astronomische Nachrichten there is no indication of the materials used. The principal result is that the observations of the comet of 1771 can be satisfied by a parabola, and that there is no reason to assume a hyperbolic orbit. If this discussion shall be found to have covered the whole ground, and to have been in all respects satisfactory, it will be difficult to claim a hyperbolic orbit for any comet hitherto observed. From *à priori* considerations such orbits are to some minds very improbable, except the comets have, in coming to the sun, passed near and behind some disturbing planet. But of course such considerations must give way if there be any well-established instance of a hyperbolic cometic orbit. H. A. N.

3. *Celestial Charts made at the Litchfield Observatory of Hamilton College;* by C. H. F. Peters. Nos. 1–20.—These charts are designed to represent portions of the sky as accurately and completely as the 13-inch refractor, which with a power of 80 in a clear sky shows stars of about the 14th magnitude, would permit.

Each chart covers 20 minutes in right ascension, and 5° in declination, with overlapping margins. The scale is 60 millimeters to a degree. The charts are limited always by the 5°, 10°, 15°, etc., and $0^m$, $20^m$ and $40^m$, so that they will easily form portions of a complete atlas. In this respect they differ from Chacornac's charts which lie along the ecliptic, and though limited by the same round numbers of minutes, are not so limited in declinations. Very little ground is common to Peters' and Chacornac's charts so far as published.

Professor Peters' charts, are in general, at some distance from the Milky Way, and are not to be strictly taken as giving a fair average density of the stars. From a count of several portions taken at random we find that a density equal to that of the charts would, if carried over the whole heavens, give nearly 5,000,000 stars.

The charts were begun in 1860, but each one has undergone a scrupulous last revision at a recent date. It is in the making of these charts that Professor Peters has discovered so many small planets. To the public he is known only by these discoveries. But the making of the charts, of which these twenty are the first instalment only, must be regarded as Professor Peters' great con-

tribution to astronomy. He has done all the work, observations, reductions, drafting, etc., without assistance, and has published the charts at his own expense for gratuitous distribution. There is a quiet expression of confidence in the accuracy and permanence of his work when he says that he wishes his charts to serve in future ages as a sure basis for drawing conclusions with respect to changes going on in the starry heavens.

---

## Obituary.

Titus Coan.—Rev. Titus Coan died on the first of December last, in his eighty-second year, at Hilo, Hawaii, where for nearly forty-eight years, he had labored as a faithful, large-hearted Christian missionary.

Throughout his residence at Hilo he had also another object of care and deep interest in the volcanic mountain at whose foot he lived. With each eruption or unusual display at Kilauea, he was the first on the ground to observe and report the movements; and three times he ascended to the scenes of the eruptions connected with the summit crater. Though not a geologist, his accounts have always been of geological value. He was the principal historian of the great eruption of Kilauea in 1840—his account appearing in the Missionary Herald for 1841 (p. 283); and also of the summit eruption of 1843 (id. 1843, and Dana's Exploring Expedition Geol. Rep., 1849, p. 209), when the flow was uninterrupted for twenty-five miles and continued for six weeks. It was after the latter eruption that Mr. Coan made the very important observation, confirmed by others and repeated in his mention of later eruptions, that Kilauea, although 10,000 feet lower in level than the summit crater, showed no change, no signs of sympathy whatever. Mr. Coan's first letter in this Journal appeared in vol. xiii (2d Ser.), 1852. After that they occur in volumes xiv (1852), xv (1853), xviii (1854), xxi (1856), xxiii (1857), xxv (1858), xxvii (1859), xxix (1860), xxxv (1861), xxxvii (1864), xl (1865), xli (1866), xliii (1867), xlvi (1868), xlvii (1869), xlix (1870), and in the 3d Series, vols. ii (1871), iv (1872), v (1873), vii, viii (1874), xiv (1877), xviii (1879), xx (1880), and xxi, xxii (1881); the first, written when he was forty years of age and the last (which is but an extract from his valued communication, because previous notices had given many of the facts) when he was eighty. Mr. Coan's life was full of activity and of great accomplishments among the people of Hawaii, and he has his reward. Honor is due his name from science for his valuable and long continued observations on the Hawaiian volcanoes.